·Instantaneous and Time-Dependent
Response and Strength
of Jointless Bridge Beams

by

Francisco P. S. L. Gastal

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Co-Chairman of Advisory Committee

ABSTRACT

GASTAL,FRANCISCO P.S.L. - Instantaneous and time-dependent response and strength of jointless bridge beams (Under the direction of Dr. Paul Zia and Dr. Ajaya K. Gupta).

The purpose of this study was to develop a generalized numerical solution for the analysis of deck-continuous, composite, multi-span bridge girders without joints. A finite element computer program has been developed, with the capability of performing instantaneous and time-dependent response analyses, and strength analyses, for a general type of bridge beams. Steel, reinforced or prestressed concrete girders, topped by a reinforced concrete deck-slab, under various sequences of construction and with different types of continuity may be equally analyzed by the proposed solution.

An isoparametric beam element and a connection, spring-like element, have been modified for modeling the nonlinear intrinsic characteristics of the materials, as well as accounting for the presence of mild steel reinforcements, prestressing tendons and the effects of cracking. Time-dependent properties of the comprising materials are assumed to follow the simplified models suggested by the American Concrete Institute and Prestressed Concrete Institute. The effects of a superimposed temperature gradient are included also in the analysis.

A thorough description of the problem and of the properties assumed in modeling the materials is given first, followed by the development of the finite element formulation. The proposed solution is validated by the analyses of ten different beams, with comparisons being made with available analytical and experimental data. Two different cases of deck-continuous, jointless, multi-span beams are investigated and their performances are compared to the extreme situations of non and full continuity. Their behaviors have been found to be very satisfactory under dead and service load conditions. Under vertical loading, the response of a deck-continuous beam may be comparable to the response of a non- or fully-continuous beam, depending primarily on the imposed supporting conditions.

This work is fondly dedicated to my father, whom I shall not see again, and to my dear wife, whose love and support have made it all possible.

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F.Gastal

North Carolina State University

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1. INTRODUCTION

1.1 Background

The use of jointless construction [1,2] for composite bridge beams is being recognized as a possible solution for the persistent bridge maintenance problems due to the existance of expansion joints [3,4]. Such joints, until not long ago taken as an indispensable design requirement for the proper behavior of bridge beams, have always been a cause for deterioration of such members [5]. It is virtually impossible to prevent water and debris from entering these man-made openings, damaging and eventually even completely destroying some vital parts of a bridge [5], such as prestressing cable anchorage systems, beams and bearings.

Maintaining a jointed bridge is often so costly [6,7] that some bridge engineers [2] committed themselves into the daring task of eliminating joints of any sort, in constructing continuous composite bridges. Some short-span structures were initially built with no expansion joints at the intermediate supports, some with even no joints at all, having the beams monolitically attached to the end abutments.

In spite of the skepticism of many, the idea has been successful and those audacious designers envisioned even longer and longer structures. Nearly one thousand feet of joint-free beams have been contructed [2], and no problems due to the absence of joints have been encountered.

Continuous concrete bridges have been built traditionally by using cast-in-place construction [8], molding fully continuous members.

Continuous steel girders were also used with a concrete deck slab eventually cast on top of them. The use of precast concrete construction (8), proven efficient and economical in many cases, brought on the need for a new solution and many concrete bridges were made continuous for live load (9). By inserting massive concrete diaphragms over the piers, the initially simply supported girders become a continuous structure resisting the action of live load. This widely used procedure, however, is not very adequate for steel girders. Thus they have been constructed either as fully or non-continuous structures (10,11).

1.2 Objective

The idea of eliminating structural joints, presents yet another interesting possibility. Continuity could be obtained not by casting expensive fully-continuous beams, nor by casting concrete diaphragms connecting precast girders, but by simply casting a fully-continuous deck over the simply supported girders (2). Such an unconventional constructional procedure, illustrated in Figs. 3.12, 5.2 and 5.17, and referred herein as "Deck-Continuous Beams", may prove to be an economical solution not only for the construction of new bridges but also for the rehabilitation of old ones (6).

The study of the jointless bridge, by virtue of its complexity, requires the analysis of a wide range of variables. However, the study of a single group of jointless continuous composite bridge beams is undoubtedly a first step towards a better understanding of their behavior.

Simple and fully-continuous beams, composite or not, under linear and uncracked conditions, can be analyzed satisfactorily by standard methods of theory of structures. Under non-linear and cracked conditions, however, numerical solutions are generally necessary. When only partial continuity is obtained, as is the case of deck-continuous beams, conventional analytical methods are no longer applicable, even for the most simple situations.

With the concept of ultimate strength design, attention is focused on the determination of actual safety factors along with the proper behavior of bridges not only under service loads but also under overload conditions. Desirable behavior includes the control of cracking, deflections, camber, movements, stresses and so on, which can be obtained only from a thorough analysis including the appropriate non-linear, time-dependent material properties for all stages of loading. The objective of this study is to develop a finite element analysis capable of monitoring all of the above, so as to investigate the behavior of deck-continuous beams.

1.3 Scope

Many numerical procedures using the finite element method can be found in the literature. They are capable of analyzing simple span as well as fully-continuous structures, some proposed for steel structures, others for reinforced or prestressed concrete structures, and even some with more general applicability. The analysis of deck-continuous beams, however, requires some special treatments not found in any of the existing numerical solutions. It also needs the capability of analyzing different types of continuities, materials and loading effects.

For such a purpose, a finite element numerical solution for the analysis of jointless beams is proposed in the present study. The beams may also be composite, continuous or not, in steel, reinforced or prestressed concrete. Girders may be pre- or post-tensioned, fully or partially prestressed, with bonded tendons. Various constructional sequences may be studied, supporting conditions may be varied, and different loading arrangements assumed. Instantaneous and time-dependent responses are obtained. Time-dependent material properties may be varied, and temperature effects can be included.

1.4 Review of Available Analytical Procedures

This section presents a brief review of the available analytical and numerical procedures which have been proposed for the analysis of reinforced and prestressed concrete beams. Some are merely methods for estimating losses of prestress, others intended for obtaining elastic deformations and also inelastic and time-dependent deflections. A few analytical and numerical techniques, based on the finite and discrete element methods, suitable for the analysis of continuous bridge beams are also mentioned. No chronological order is followed and descriptions are brief. More detailed information can be found in the original works.

1.4.1 GROUNI

Grouni (12) developed a set of expressions to predict the prestress loss of noncomposite prestressed concrete beams, taking into account creep and shrinkage of concrete and relaxation of prestressing steel. The effects of ordinary reinforcements were neglected in the procedure.

1.4.2 HUANG

Huang [13] proposed a direct method for estimating prestress losses in pre-tensioned noncomposite members, avoiding a step-by-step method. Several expressions were introduced to account for the effects of creep and shrinkage of concrete and relaxation of prestressing steel.

1.4.3 TADROS

Tadros, et al [14] suggested a procedure for predicting prestress losses, taking into consideration the effects of continuous reduction of prestressing stress due to creep and shrinkage of concrete and relaxation of steel, by a recovery parameter and a relaxation reduction factor.

1.4.4 ZIA

Zia, et al [15] presented equations for estimating pretress losses due to elastic shortening, creep and shrinkage of concrete and relaxation of prestressing steel for both pre- and post-tensioned members with either bonded or unbonded tendons. The equations were applicable to normal design conditions and estimated the various types of prestress loss, rather then a lump sum value.

1.4.5 GHALI and TREVINO

Ghali and Trevino [16], studying the relaxation effect in prestressing steel, proposed a relaxation reduction coefficient to be employed as a multiplier to the intrinsic relaxation for use in prestressed concrete design. A numerical example was presented showing that the prestress loss due to relaxation in prestressed concrete members is of smaller magnitude than the intrinsic relaxation presented by a free tendon.

1.4.6 TADROS, GHALI and MAYERS

Tadros, Ghali and Mayers [17] proposed a single procedure for the prediction of time-dependent deflections in pre-tensioned precast concrete members. The method accounts for the effects of creep, shrinkage of concrete and relaxation of the prestressing steel, allowing for the presence of non-prestressing steel and considering the tension stiffening effect of concrete. Deflections are obtained by numerical integration of the curvatures. The procedure has been suggested for modification of the method used by the PCI Design Handbook [18].

1.4.7 BRANSON

Based on his previous works, Branson [19] advanced a modified step function method for calculating prestress losses, cambers, and deflections of non-composite and composite prestressed beams. Formulas were given to estimate prestress losses and camber or deflections for different types of structures. The formulas were the summation of the contribution of each factor that affects prestress losses, and cambers or deflections.

The method of analysis, for both instantaneous and time-dependent analyses, is also presented in detail in the book by Branson [20]. It includes the effects of aging, creep, shrinkage of concrete and relaxation of prestressing steel. The effects of non-prestressing steel, cracking of the sections and continuity of the structure are also taken into account. The method is developed for hand calculations, but it is also suitable for computer analysis.

1.4.8 RAO and DILGER

A method of analysis called "The Varying Stiffness Method" was proposed by Rao and Dilger [21] to predict time-dependent responses of simply supported pre-tensioned members, both noncomposite and composite. The method takes into account aging, creep and shrinkage of concrete and relaxation of prestressing steel. In estimating creep strains, the method uses a modified version of the superposition principle. It is also assumed that creep is proportional to stress. Stress-strain relationships of concrete and prestressing steel are assumed linear in the range of stress level of interest.

1.4.9 NAAMAN

Naaman [22] proposed a simplified method for the prediction of time-dependent deflections of prestressed concrete beams, called "The Pressure Line Method". The method considers the beams subjected to a compressive force following the profile of the pressure line instead of that of the tendons. A lump sum estimate of the total time-dependent prestress loss, and its percentage value with time, are assumed a priori, and a single sustained loading comprising the combined effects of sustained external moments and prestressing moments is considered.

1.4.10 PCI

The PCI Committee on Prestress Losses [23] also recommended a step-by-step method of estimating prestress losses in both pre-tensioned and post-tensioned concrete members. Total prestress losses could also be computed using a simplified method where several equations were given for different types of materials and methods of tensioning.

For composite sections, the effects of differential shrinkage and differential creep between deck slab and precast beams are difficult to obtain. The change of stiffnesses of indeterminate structures due to time-dependent properties of materials may change the bending moments caused by external loads in any section. These effects, however, are not considered in most of the above mentioned prestress loss methods.

Adapting the step-by-step method, the time dependent response problem of prestressed members is reduced to a series of instantaneous, age-corrected, response problems. The instantaneous load responses of a general prestress beam can be best estimated numerically through the use of a digital computer.

1.4.11 SINNO and FURR

Sinno and Furr [24] developed a computer program to predict the time-dependent responses of noncomposite and composite simply supported pre-tensioned beams. The step-by-step procedure together with the rate of creep method were used in estimating prestress losses and camber of the members. The separations method for predicting responses of composite sections, as proposed by Branson [25], was used in estimating the effects of the differential shrinkage and creep. The method assumed linear stress-strain relationships for both concrete and steel, it did not take into account the effects of concrete aging nor the effects of external loading.

1.4.12 MOSSOSIAN and GAMBLE

Mossosian and Gamble [26] developed a computer program based on a step-by-step procedure which iteratively estimates the time-dependent behaviors of both noncomposite and composite prestressed concrete members. The superposition method and the rate of creep method, taking into account the effect of concrete aging, were used in estimating the creep strains. In developing the computer program, linear stress-strain relationships for both concrete and steel were assumed. The aging effects, creep and shrinkage of concrete were considered, but relaxation of prestressing steel was neglected. The program was later revised and updated by Fadl and Gamble [27], to predict the time-dependent behaviors of noncomposite and composite pre-tensioned girder bridges.

Various versions of the direct stiffness method of structural analysis, in which structural elements are modeled as finite elements or discrete elements, are used widely to solve nonlinear structural problems by an iterative approach. Many finite element computer programs have been written for the analysis of reinforced concrete beams and frames [28,29,30,31,32], although many of them are not suitable for the analysis of precast composite members nor for the analysis of time-dependent behaviors. An extensive list of references may be found in the report by the American Society of Civil Engineers [33].

1.4.13 ATKINS, PIERCE, CHANG, LO and WANG

The discrete element method for the analysis of elastic and inelastic prestressed concrete members was used by Atkins (34), of elastic or inelastic prestressed concrete members with unbonded tendons by Pierce (35), and of composite prestressed concrete members by Chang (36), Lo (37) and Wang (38). These analyses, however, were based on linear stress-strain relationships for both concrete and prestressing steel, and were proposed for obtaining instantaneous responses only.

1.4.14 FREYERMUTH

Based on the work by Mattock and Kaar (39), Freyermuth (9) developed a simplified procedure to account for the effects of differential creep and differential shrinkage in the analysis and design of precast, composite, prestressed concrete girders, made continuous for live load only. In this type of construction, positive moments may develop over the piers due to creep in the prestressed girders, as well as due to loads in the remote spans. This may be partially counteracted by negative moments resulting from differential shrinkage between the cast-in-place deck slab and the precast girders.

Freyermuth's procedure assumes that the effects of creep under prestress and dead load can be evaluated by an elastic analysis assuming that the girders and slab are cast and prestressed as a monolitic continuous beam. The conjugate beam theory is used to calculate the various fixed end restraint moments, due to shrinkage, prestressing and dead loads, and the final restraining moments are then obtained by moment distribution. The moments so obtained are, then, multiplied by creep factors to allow for the effects of creep. Those creep factors are evaluated in terms of intrinsic creep potential of the concrete materials, volume to surface ratio of the member, and ages of casting and prestressing. It is worth noting that this procedure, if correct, is only applicable to members under service loads with linear and uncracked conditions. Furthermore, as any other elastic analysis, it is not suitable for the case of deck-continuous beams being considered herein.

1.4.15 QIU, CHUNFU and JINHUAN

Qiu, Chunfu and Jinhuan [40] have very recently reported a new version of a computer program for the analysis and design of long span prestressed concrete bridges, the SABRIJ-B83. The program, which also uses the "CAD" techniques, is suitable for both static linear and nonlinear analyses of any structural system of bridges which could be considered as plane frames, e.g. continuous-beams, -arches, -trusses, T-frames, cable-stayed and enclosed frames. It also accounts for the effects of various loading conditions, temperature, shrinkage, creep, prestress losses and support settlements. Although showing remarkable versatility, the program SABRIJ-B83, as by its description, may not be suitable for the problem in question, i.e. deck-continuous beams.

1.5 Outline of Remainig Chapters

In the next chapter the mechanical properties of the materials used in this study are described. Methods used in estimating instantaneous uniaxial load responses of concrete, reinforcing steel and prestressing steel, and time-dependent responses, i.e. aging, creep under constant and variable stresses, and shrinkage of concrete and relaxation of steel, are presented.

Chapter III reviews the fundamental concepts which are used as the basis for the development of the proposed solution. The formulation of two finite elements used are thoroughly described, as well as the methods adopted for the analysis of loading, prestressing, support displacements, temperature and time-dependent effects.

Various example problems illustrating the capability and the validity of the proposed numerical solution are pre ented in Chapter IV. The instantaneous and time-dependent responses, and strength, of several different beams are analyzed and compared to experimental date reported in the literature.

Chapter V illustrates the applicability of the proposed solution to the study of deck-continuous beams. Two distinct example problems are investigated and particular conclusions are drawn. A summary of the study, final conclusions and some suggestions for further research are found in Chapter VI. Appendices A, B, C and D show input and output details, a complete listing of the developed program and a sample input and output, respectively.

2. MATERIAL PROPERTIES

A composite bridge beam is generally composed of concrete, mild steel, for the girders or for reinforcement, and prestressing steel. In order to accurately predict the behavior of the beam under any loading condition, constitutive relations, i.e. stress-strain-time relationships for the materials that comprise the beam, must be available. In the following sections the expressions representing the uniaxial constitutive laws of concrete, prestressing steel, and reinforcing steel will be briefly reviewed. The presentation will be helpfull in determining the material properties for estimating the responses of the structures when only limited experimental data are available.

2.1 Concrete

2.1.1 Constitutive Relationship for Loading and Unloading

2.1.1.1 Compressive Behavior

The instantaneous compressive stress-strain relationship of concrete depends on so many factors that it is not feasible to establish the relationship for a particular concrete from its constituents, curing conditions, and ambient conditions. The common method for determining the relationship is to perform a series of compression tests on cylinders taken from the same mix and stored in the same ambient conditions as the structure. But a complete stress-strain curve of concrete in compression is not easely obtained [41,42,43]. Concrete cylinders under uniaxial compression fail suddenly when loaded beyond their ultimate strength. A specially designed equipment is needed to obtain the descending branch of the stess-strain curve, i.e. the portion of the stress-strain curve exceeding the strain corresponding to the ultimate strength.

Many empirical expressions representing the complete concrete stress-strain curves have been proposed by several investigators (44,45,46,47), some will be listed herein, but more extensive references can be found in the reports by Popovics (48) and Sargin (49). Note that the expressions will be changed such that they are consistent with the sign convention used in this thesis, i.e. compressive stress and strain are negative and tensile stress and strain are positive.

Hognestad (44,50), after extensive tests of concrete columns subjected to combined bending and axial load, proposed a stress-strain relationship composed of a parabolic ascending branch and a straight descending branch, shown in Fig. 2.1.

For $0 \geqslant \varepsilon \geqslant \varepsilon_0$

$$f_c = f_c'' \, [\, 2\,\varepsilon/\varepsilon_0 - (\,\varepsilon/\varepsilon_0\,)^2]$$

$$E_{ci} = 1\ 800\ 000 + 460\ |f_c'|$$

$$E_c = 2\ |f_c''\ |(\,1 - \varepsilon/\varepsilon_0)\ (\,1/\varepsilon_0\,)$$

For $\varepsilon_0 > \varepsilon \geqslant \varepsilon_u$

$$f_c = f_c''\ (\,\varepsilon_u - 0.85\ \varepsilon_0 - 0.15\ \varepsilon)/(\,\varepsilon_u - \varepsilon_0)$$

$$E_c = 0.15\ f_c''\ /(\,\varepsilon_u - \varepsilon_0)$$

Where

ε = Concrete compressive strain

f_c = Concrete compressive stress at strain ε

f_c'' = Maximun compressive stress = 0.85 f_c''

f'_c = Concrete cylinder strength

ε_0 = Concrete strain at maximum stress f''_c

= $2 f''_c / E_{ci}$ in/in

E_{ci} = Initial modulus of elasticity

E_c = Modulus of elasticity at stress f_c

ε_u = Ultimate compressive strain

= -0.0038 in/in

Kent and Park (45,51), proposed a stress-strain relationship for unconfined or confined concrete, which assumes that the ascending part of the curve is represented by a second degree parabola and that the confining steel has no effect on its shape, nor on the strain at maximum stress. It is also assumed that the maximum stress reached by the concrete is the cylinder strength f'_c. The descending branch of the proposed curve is modeled by straight lines with different slopes for confined and unconfined concretes, as shown in Fig. 2.2 .

The relationship can be represented by the following expressions:

For $0 \geqslant \varepsilon \geqslant \varepsilon_0$

$$f_c = f'_c \left[2 \varepsilon / \varepsilon_0 - (\varepsilon / \varepsilon_0)^2 \right]$$

For $\varepsilon_0 > \varepsilon \geqslant \varepsilon_{20c}$

$$f_c = f'_c \left[1 - Z (\varepsilon - \varepsilon_0) \right]$$

$$Z = 0.5 / (\varepsilon_{50u} - \varepsilon_0) \quad , \quad \text{unconfined}$$

$$Z = 0.5 / (\varepsilon_{50c} - \varepsilon_0) \quad , \quad \text{confined}$$

For $\varepsilon_{20c} > \varepsilon$

$$f_c = 0.2 f'_c$$

Where

Z = Slope of the descending branch of the stress-strain relationship.

ε_{50u} = Strain at 0.5 f_c' on the descending branch for unconfined concrete.

ε_{50c} = Strain at 0.5 f_c' on the descending branch for confined concrete.

The strain ε_0 was assumed to be equal to -0.002 in/in, ε_{50u} and ε_{50c} were found from the analysis of test results from various investigators, e.g. Soliman and Yu (52), Roy and Sozen (53), Bertero and Felippa (54), to be as follows:

$$\varepsilon_{50u} = -\ (\ 3 + 0.002\ \ |f_c'\ |)/(\ |f_c'\ |- 1000\ ) \qquad \text{in/in}$$

$$\varepsilon_{50c} = \varepsilon_{50u} - 0.75\rho\ (\ b/s\ )^{\frac{1}{2}} \qquad \text{in/in}$$

Where

ρ = Volumetric ratio of lateral reinforcement to bound concrete
= $2\ (\ b + d\ )\ A_s\ /\ (\ b\ d\ s\ )$

b = Width of confined core

d = Depth of confined core

A_s = Cross section of one leg of lateral reinforcement

s = Longitudinal spacing of lateral reinforcement

Lee (46), in his study of inelastic behavior of reinforced concrete menbers, assumed that both ascending and descending branches of the curve could be represented by a single parabolic curve as:

$$f_c = f_c''\ [\ 2\ \varepsilon/\varepsilon_0 - (\ \varepsilon/\varepsilon_0\ )^2\ ]\ ,\ 0 < \varepsilon/\varepsilon_0 < 2$$

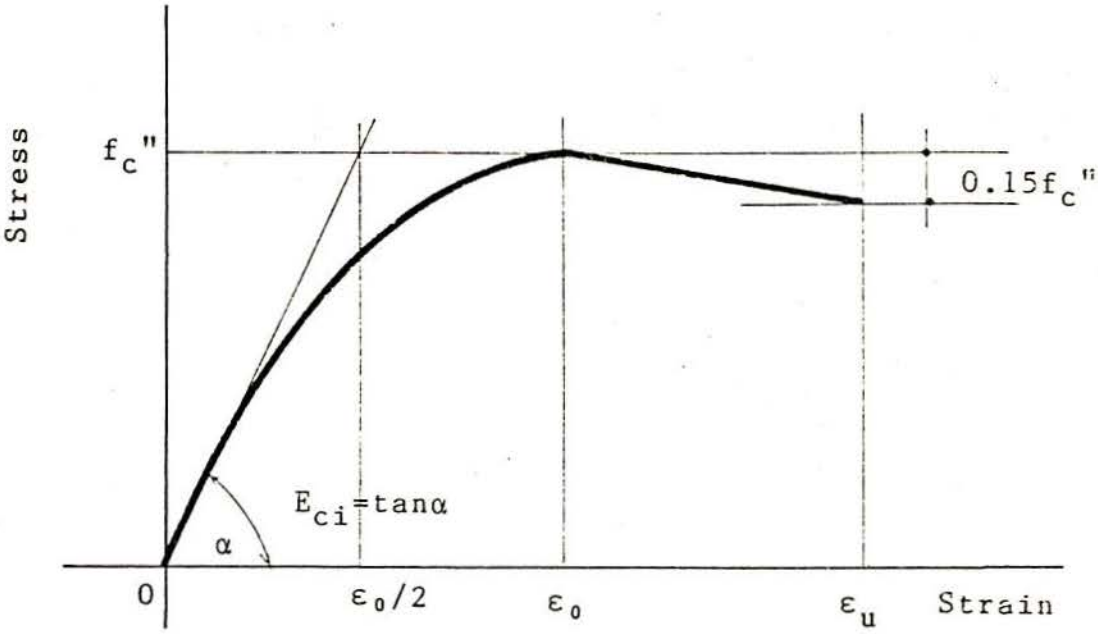


Fig 2.1 - Hognestad's stress-strain curve for concrete in compression.

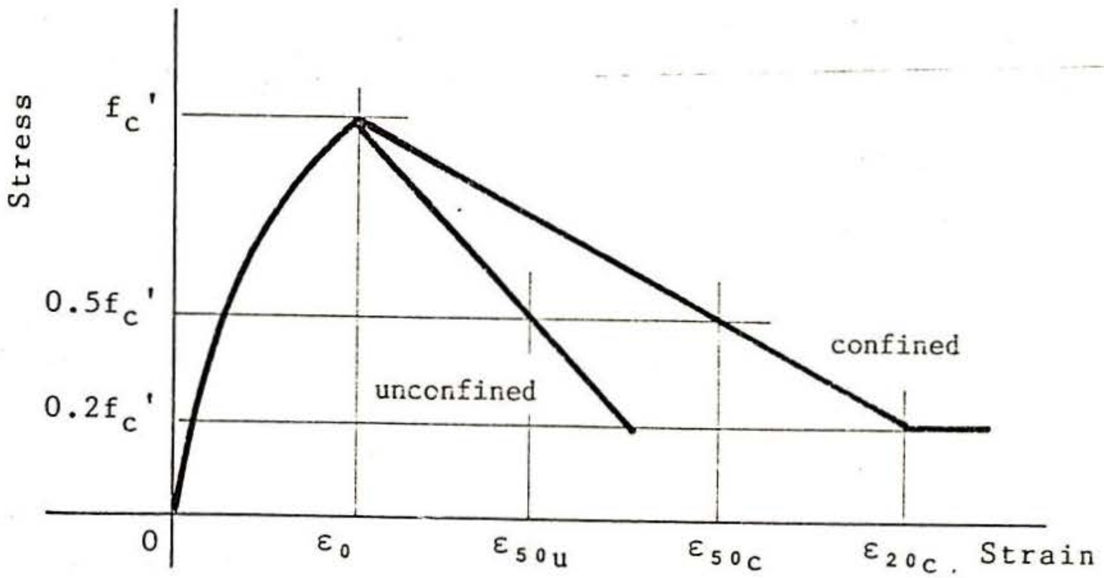


Fig 2.2 - Kent and Park stress-strain relationship for confined and unconfined concrete in compression.

Kriz and Lee [illegible] , represented the relationship by a quadratic equation as:

$$f_c^2 + a\,\varepsilon^2 + b\,f_c\,\varepsilon + c\,f_c + d\,\varepsilon = 0$$

Where the constants a, b, c, and d were empirical and estimated from uniaxial compression test data by solving four simultaneous equations. Those equations were obtained from substituting the values of the stresses correspondent to four specified strain points.

The CEB (55) , recommended an expression representing the compressive stress-strain relationship of normal weight concrete as:

$$f_c \,/\, f_c' = (\,k\,x - x^2\,)/[\,1 + (\,k - 2\,)\,x\,]$$

$$k = E_{ci}\,\varepsilon_0 \,/\, f_c'$$

Where

$x = \varepsilon/\varepsilon_0$

ε_0 = Strain at maximum stress f_c'

E_{ci} = Initial modulus of elasticity

$= 10450\ (\ |f_c'| + 8\ )^{\frac{1}{2}}$, MPa

The values of ε_0 are found to range from -0.002 to -0.0025 in/in . The value of ε_0 of -0.0022 in/in is recommended for the stress-strain curve. The values of the ultimate strain ε_u are found to range from -0.0035 to -0.007 in/in, and the values of the stress at ultimate strain to range from 0.75 f_c' to 0.25 f_c'

The ACI [56] recommends the analysis of uncracked sections, under service loads, by the linear elastic theory assuming a constant relationship between strains and stresses as:

$$E_c = f_c \ / \ \varepsilon_c$$
$$= W^{3/2} \, 33 \ (\ |f'_c \ |)^{\frac{1}{2}}$$

Where

f'_c = Concrete cylinder strength in psi

W = Concrete weight, ranging from 90 to 155 lb/cu.ft

For normal weight concrete the modulus of elasticity E_c may be approximated by:

$$E_c = 57000 \ (\ |f'_c \ |)^{\frac{1}{2}} \ .$$

For structural members, under the combined action of bending and axial load, it suggested the use of a rectangular stress block, within the compression zone, for the calculation of their ultimate capacity. This stress block extends, with constant compressive stress f''_c , from the extreme fiber to a depth "a" into the compression zone, such that

$$f''_c = 0.85 \ f'_c$$
$$a = \alpha \ c$$
$$\alpha = 0.85 \qquad , \ f'_c \leq 4000 \text{ psi}$$
$$= 0.85 - (\ 0.05/1000 \ ) \ (\ f'_c - 4000 \ ) \geq 0.65 \quad , \ f'_c \geq 4000 \text{ psi}$$

Where

f'_c = Concrete cylinder strength

f''_c = Maximum compressive strength

c = Depth of the compression zone

a = Depth of the rectangular stress block

α = Ratio a/c

The resultant force from this rectangular stress block is assumed to coincide with the resultant force from the actual concrete stress distribution in the compression zone.

From the existing experimental data and the stress-strain relationships proposed by various investigators, some of them previously mentioned, the following characteristics of the stress-strain relationship for a normal weight concrete specimen in compression are observed:

a) Compressive stress increases as compressive strain increases, at a decreasing rate, up to the maximum compressive stress, f''_c , of the concrete, where the slope of the stress-strain curve is equal to zero.

b) The maximum compressive stress, f''_c , is taken as a fraction of the maximum compressive strength of the specimen f'_c , ranging from 0.85 f'_c to f'_c .

c) Most investigators gave the strain at the maximum compressive stress ε_0 independent of the strength and the modulus of elasticity of concrete. ε_0 ranges from -0.002 to -0.0025 in/in.

d) For compressive strains greater than ε_0 , compressive stresses decrease as compressive strains increase. The descending branch of the stress-strain curve can be adequately represented by a straight line until the stress drops to a certain level. Concrete can sustain that stress level at relatively large strains, property refered to as ductility. The slope of the descending branch depends on the stength of the concrete and the degree of lateral confinement.

Several expressions have been proposed to estimate the modulus of elasticity for concrete, E_c . Sargin (45) listed the following expressions:

GRAF	$E_c = 4.92\ \lvert f'_c \rvert .10^6 /(1970 + \lvert f'_c \rvert)$
ROS	$E_c = 7.82\ \lvert f'_c \rvert .10^6 /(2133 + \lvert f'_c \rvert)$
JENSEN	$E_c = 8.00\ \lvert f'_c \rvert .10^6 /(2000 + \lvert f'_c \rvert)$
HOGNESTAD	$E_c = 1\ 800\ 000 + 460\ \lvert f'_c \rvert$
WALKER	$E_c = 66\ 000\ (\lvert f'_c \rvert)^{\frac{1}{2}}$
PAUW	$E_c = 33\ W^{3/2}\ (\lvert f'_c \rvert)^{\frac{1}{2}}$
SAENZ	$E_c = (\lvert f'_c \rvert)^{\frac{1}{2}} .10^5 /[1 + 0.006 (\lvert f'_c \rvert)^{\frac{1}{2}}]$

where, E_c and f'_c are in psi, and W is in pcf.

Pauw's expression for E_c is somewhat more general than the others and was adopted by the ACI (56) .

A number of expressions have also been proposed to estimate the ultimate strain of concrete under compression. Some of them are:

HOGNESTAD	$\varepsilon_u = 0.0038$
BRANDTZAEG	$\varepsilon_u = (6.88 + 0.77 \lvert f'_c \rvert / 1000).10^{-3}$
SALIGER	$\varepsilon_u = (1.75 \lvert f'_c \rvert).10^{-6}$

JENSEN $\varepsilon_u = |f'_c| \,/(1 - \beta) E_c$

ROS $\varepsilon_u = (3.5 - 2860 \,/\, f'_c) .10^{-3}$

CHANBAND $\varepsilon_u = 0.0036$

where E_c and f'_c are in psi.

The ACI (56) has adoped a more conservative value of $\varepsilon_u = 0.003$ in/in.

As it can be seen from this brief review, several different shapes of stress-strain curves have been proposed for the behavior of concrete under compression. From the existing experimental data, it has been observed that none of the proposed stress-strain relationships can fit accurately the actual concrete stress-strain curve for all different loading conditions.

Hognestad's (44) stress-strain relationship (a parabolic ascending part, up to a maximum stress of $f''_c = 0.85\, f'_c$ and a straight line descending part, up to an ultimate strain of -0.0038 in/in and $f_c = 0.85\, f''_c$) has been adopted by a number of investigators with the result of the analysis in fairly good agreement with experimental data.

The present study does not propose a new stress-strain relationship for concrete under compression, nor does it intend to compare the effects of the use of different relationships on the behavior of the structures studied. However, two different stress-strain relationships for concrete under compression have been adopted and can be used alternatively for performing the analyses.

For a more refined analysis, although somewhat more time consuming, the Hognestad's stress-strain relationship is chosen. The initial modulus of elasticity for concrete can be aproximated by either: the Hognestad's proposed expression

$$E_c = 1\ 800\ 000 + 460\ |f'_c|$$

or by the ACI's adopted expression

$$E_c = 33\ W^{3/2}\ (\ |f'_c|\ )^{\frac{1}{2}}$$

when experimental data for this particular property are not available.

For a somewhat less time consuming analysis, or for a preliminary, supposedly less refined, analysis a bilinear stress-strain relationship can be adopted, as shown in Fig. 2.3, and with the following equations:

For $0 > \varepsilon > \varepsilon_0$

$$f_c = E_{ci}\ \varepsilon$$

For $\varepsilon_0 > \varepsilon > \varepsilon_u$

$$f_c = f'_c$$

where

f_c = Concrete stress at strain ε

f'_c = Maximun concrete cylinder strength

E_{ci} = Initial modulus of elasticity

= $33\ W^{3/2}\ (\ |f'_c|\ )^{\frac{1}{2}}$ or as obtained experimentally

$\varepsilon_0 = f'_c\ /\ E_{ci}$

ε_u = -0.003 or as obtained experimentally

The use of any other stress-strain relationship, including the option of some curve fitting in available experimental data, is possible to be incorporated in the proposed analysis, without any major

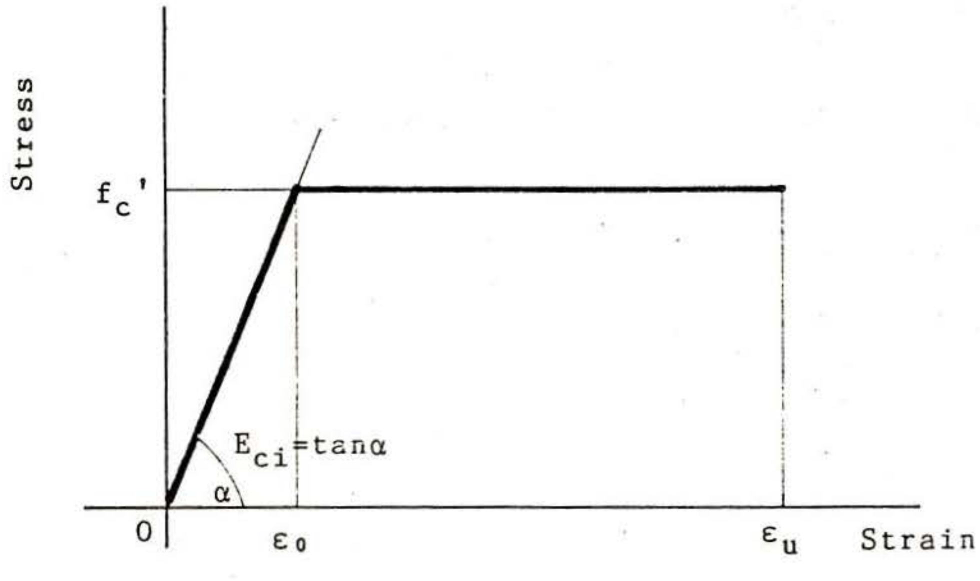


Fig 2.3 - Bilinear stress-strain relationship for concrete in compression.

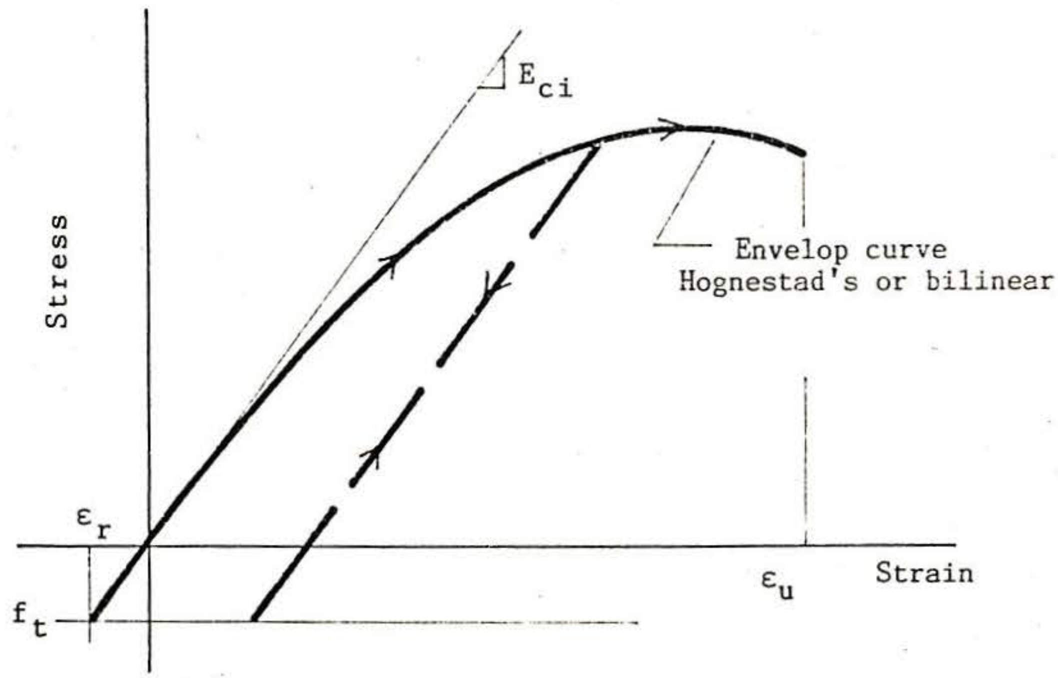


Fig 2.4 - Complete stress-strain relationship for concrete under tension and compression, for loading, unloading and reloading.

programming effort.

For a more accurate modeling of the behavior of concrete in a structure subjected to bending and axial load, the complete stress-strain relationship is needed. The complementary part of the stress-strain curves outlined priviously, is refered to as the tensile stress-strain relationship of concrete.

2.1.1.2 Tensile Behavior

Tensile strength of concrete is usually neglected in conventional reinforced concrete theory. Its magnitude is so small that the stress induced by shrinkage in reinforced concrete members may exceed the tensile strength and cracks may develop even before the member is loaded. It does seem logical to neglect its effect in reinforced concrete members. However, in a prestressed concrete member, concrete stress can be controlled in such a way that under service load conditions it rarely exceeds the tensile strength of concrete. Because the stiffness of the member after it is cracked is greatly reduced, to neglect the tensile strength of concrete would greatly affect the prediction of the response of a prestressed beam prior to cracking.

Since the tensile strength of concrete is relatively small, compared to the compressive strength, and stresses in a prestressed concrete beam are mostly in compression, the tensile stress-strain relationship for concrete may be adequately represented as a straight line at a slope equal to the initial modulus of elasticity for concrete E_{ci} up to the modulus of rupture f_r as:

For $0 \geqslant \varepsilon \geqslant \varepsilon_r$

$$f_t = E_{ci}\,\varepsilon$$

For $\varepsilon_r > \varepsilon$

$$f_t = 0$$

where

f_t = Concrete tensile stress at a strain

E_{ci} = Initial modulus of elasticity

ε_r = Concrete strain corresponding to the modulus of rupture

= $f_r \,/\, E_{ci}$

f_r = Modulus of rupture of concrete

The modulus of rupture is obtained generally by bending tests of short prismatic plain concrete beams, or by splitting tension test of concrete cylinders. The latter is also known as Brazilian test.

The accuracy of the estimate of the modulus of rupture is important, for it directly influences the cracking moment of the sections. The current trend is to express the modulus of rupture as a power function of the maximum cylinder strength as:

$$f_r = a \, |f'_c|^{\,b}$$

The ACI (56), recommends the value of a as 7.5 for normal weight concrete, 0.85 x 7.5 for sand-lightweight concrete, and 0.75 x 7.5 for all-lightweight concrete, and the value of b as 1/2. However, tensile stress ranging from 6.0 $(|f'_c|)^{\frac{1}{2}}$ to 12.0 $(|f'_c|)^{\frac{1}{2}}$ is allowed at service load for a prestressed concrete member in flexure. The deflection must be checked by a rational analysis for those higher stress levels which may produce cracking.

Some investigators [57] , based on tests on post-tensioned composite bridge girders, stated that the use of f_r equal to 7.5 ($|f_c'|$)$^{\frac{1}{2}}$ gave good indication of the positive moment cracking potential and 6.0 ($|f_c'|$)$^{\frac{1}{2}}$ worked well for the negative cracking moment and cracking at the junctions between the precast girders and the cast-in-place splice concrete. For the present study, where available experimental data are lacking, the ACI's recommendation would be used for the prediction of the concrete modulus of rupture.

2.1.1.3 Cyclic Loading

The previously mentioned stress-strain relationships for concrete were proposed to model the behavior of the material under a monotonic increase of stress with small strain increments. At any point inside a prestressed or reinforced concrete member, however, there may be a superposition of tensile and compressive strains at different times during the loading history. This may be a consequence of not only the different loading conditions but also the possible redistribution of stresses as well as the effects of time.

After an intensive investigation on concrete cylinders tested under cyclic loading, Sinha, et al [58] have observed that the action of repeated compressive loading produces a pronounced hysteresis effect in the stress-strain curve of concrete. Karsan and Jirsa [59] by testing prismatic concrete specimens, have also observed that the envelope curve of a specimen tested under cyclic loading and unloading coincides with the stress-strain curve for a specimen under monotonic loading to failure. The stress-strain path reached the envelope curve regardless of the strain accumulated prior to a particular loading cycle. Both investigators have developed a series of analytical expressions for the prediction of intermediate unloading and reloading curves obtained from the hysteresis effect. From the experimental data, however, it can be observed that during unloading and reloading at relatively low levels of strain, the stress-strain curves follow a line which is approximately paralel to the initial tangent to the envelope stress-strain curve. Such a simplification seemed reasonable and has been adopted for this study.

The assumed stress-strain relationship, then, follows a Hognestad's or a bilinear stress-strain curve under monotoninally increasing load. When unloading occurs, a straight line paralel to the initial tangent is followed. For reloading, this same line is tracked until reaching the envelope curve which is then followed for further loading. A complete picture of the assumed stress-strain relationship for concrete is shown in Fig. 2.4.

2.1.2 Types of Strain

Total strain in concrete under sustained load at any time may be considered as consisting of two types: instantaneous strain and time-dependent strain. Different definitions of the strain types may be used by different investigators. In this study, the following definitions will be used.

Instantaneous strain - The instantaneous, elastic or inelastic strain, is the strain that occurs during the changing of load. The stress-strain relationship follows a previously defined stress-strain curve. In the event of the changing of the stress-strain relationship, with time, the stress-strain curve at the time of consideration will be followed.

Time-dependent strain - The time-dependent strain is the one that occurs in excess of the instantaneous strain. It can be further subdivided into two components: creep or creep recovery, the increase or decrease in strain with the time under sustained load or removal of load, and shrinkage strain, the change in strain with time due to the change in moisture content of concrete.

Creep or creep recovery and shrinkage occur simultaneously and are not independent of one another, thereby limiting the application of the principle of supperposition. Shrinkage tends to increase the magnitude of creep and vice-versa [60,61]. However, for convenience and simplicity, they are usually assumed to be independent and additive.

Shrinkage is regarded as the portion of time-dependent strain occurring in a specimen due to the change in moisture content of concrete, if the specimen is not loaded. Creep or creep recovery is regarded as the portion of time-dependent strain in excess of shrinkage, caused by sustained load or removal of sustained load.

It is rather difficult, if not impossible, to experimentally obtain the effect of creep alone in a continuously loaded concrete specimen. It is necesssary to assure that no shrinkage occurs during the process which can only be accomplished by keeping in the specimen the same original moisture content. By loading the specimen, however, this moisture content may be varied and some load induced shrinkage [61] may occur, increasing the strain supposedly attributed to creep. On the other hand, there is no such interaction problem in pure shrinkage tests, in which the specimen is free of load.

Commonly, two separate tests are conducted, one for pure shrinkage and one for combined creep and shrinkage, and the results are linearly subtracted, attributing the difference to pure creep. The interaction between creep and shrinkage is therefore neglected and the resultant creep coefficients may be overestimated.

2.1.3 Time-dependent Properties

2.1.3.1 Creep Under Constant Stress

Creep of concrete under constant sustained stress follows a specific pattern. Experimental evidence indicates that the creep strain occurring over a given period of time is proportional to the applied stress, up to some limiting stress level. Researchers are in conflict with respect to the stress level at which the linearity between creep and the applied stress ceases. Some indicate loss of linearity at stresses as low as 0.2 f_c' , others suggest a value of 0.5 f_c' and even 0.9 f_c' . Rate of creep decreases with time providing that stress is not high enough to cause progressive internal cracking, which leads to time failure. Creep tends to approach a finite limiting value. Although some experimental data show that creep deformation continues over periods as long as thirty years, the rate of creep at later ages is so small that it would not cause any significant deformation.

Attempts have been made to represent the creep-time response of concrete with mathematical functions so that the amount of creep under sustained load may be estimated without performing long term creep measurements. Extensive references may be found in the report by Corley (62), ACI committe 209 (63) and the book by Neville (60).

Four different types of creep functions have been proposed by various investigators: power functions, logarithmic functions, exponential functions and hyperbolic functions.

The ACI Committe 209 (63), based on the work by Branson and Christiason (64), represented the creep-time relationship by a hyperbolic function as:

$$C_t = C_u \, t^b / (a + t^b)$$

The empirical constants, a and b, and the ultimate creep coefficient C_u are functions of material properties, geometry, ambient conditions and the time of loading. The values of a are found to range from 6 to 30, b ranges from 0.4 to 0.8 and C_u from 1.3 to 4.15. To estimate creep a standard creep equation is recommended,

$$C_{t,t'} = C_u \, (t - t')^{0.6} / [10 + (t - t')^{0.6}]$$

The equation is for concrete with 4 in or less slump, in 40 percent ambient relative humidity, with minimun thickness of 6 in or less, with loading age of 7 days. Concrete is moist cured or steamed cured for 1 to 3 days. The suggested average value of C_u is 2.35. In the above expressions t and t' are expressed in days and stand for age of concrete and age of concrete when loaded, respectively.

Correction factors are suggested for concrete under different conditions, as listed below.

For moist cured concrete -

$$CC_{LA} = 1.25\ t'^{\ -0.118} \quad , \quad t' > 7 \text{ days}$$

For steamed cured concrete -

$$CC_{LA} = 1.13\ t'^{\ -0.118} \quad , \quad t' > 7 \text{ days}$$

where CC_{LA} is the creep correction factor for age of concrete at loading t' days. Ambient relative humidity greater than 40 percent -

$$CC_H = 1.27 - 0.0067\ H \quad , \quad H > 40\ \%$$

where CC_H is the creep correction factor for ambient relative humidity H percent. Minimun thickness of the member -

$$CC_T = 1.14 - 0.023\ T \quad , \quad \text{for} < 1 \text{ year}$$

$$CC_T = 1.10 - 0.017\ T \quad , \quad \text{for ultimate}$$

where CC_T is the creep correction factor for member thickness T in in.

Slump test, S in in -

$$CC_S = 0.82 + 0.067\ S$$

where CC_S is the creep correction factor for consistency of concrete.

Percent of fine agregate by weight -

$$CC_F = 0.88 + 0.24\ F$$

where CC_F is the creep correction factor for percent of fine aggregate F of concrete. Air content, A, in percent -

$$CC_A = 1.0 \quad , \quad A < 6\ \%$$

$$CC_A = 0.46 + 0.09\ A \quad , \quad A > 9\ \%$$

where CC_A is the creep correction factor for air content A of concrete.

The PCI Committee on Prestress Losses (23), recommended a method in determining prestress losses using a series of curves. The prestress loss due to creep may be converted in to the equivalent creep strain by dividing the loss by the modulus of elasticity of the prestressing steel (28.10^6 psi). Creep may then be written as follows:

$$(\varepsilon_c)_{t,t'} = (c_\varepsilon)_u \; CC_T \; CC_{LA} \; (g_c)_t \; f_c$$

where

CC_T = Correction factor for size and shape of member, a function of volume to exposed surface ratio.

CC_{LA} = Correction factor for age of loading and legth of curing.

$(g_c)_t$ = Function representing creep with time evaluated at time t.

For the curves representing the factors CC_T , CC_{LA} and the function $(g_c)_t$, refer to reference (23) .

The ultimate creep strain per unit stress, $(c_\varepsilon)_u$ may be estimated as follows:

Normal weight concrete, moist cured not exceeding 7 days-

$$(c_\varepsilon)_u = 3.455 \,.10^{-6} - 7.273 \,.10^{-13} \, E_c > 4.00 \,.10^{-6}$$

Normal weight concrete, accelerated curing -

$$(c_\varepsilon)_u = 2.291 \,.10^{-6} - 7.273 \,.10^{-13} \, E_c > 4.00 \,.10^{-6}$$

Lightweight concrete, moist cured not exceeding 7 days -

$$(c_\varepsilon)_u = 2.764 \,.10^{-6} - 7.273 \,.10^{-13} \, E_c > 4.00 \,.10^{-6}$$

Lightweight concrete, accelerated curing -

$$(c_\varepsilon)_u = 2.291 \,.10^{-6} - 7.273 \,.10^{-13} \, E_c > 4.00 \,.10^{-6}$$

where $(c_\varepsilon)_u$ is in in/in/psi.

The most complete creep prediction procedures are those recommended by the ACI Committee 209 [63], the PCI Committee on Prestress Losses [23], and the CEB [55]. The latter two are not listed here.

In practice, creep-time response of a specimen can be conveniently estimated using one of this procedures with minimal data. Because of the scattering of the experimental data, as suggested by the range of the empirical constants for the function recommended by the ACI Committee 209, this procedures may not give enough accuracy. It may be preferable, although costly, to perform a short term test simulating the actual atmospheric conditions, and use the creep-time curve in the form of one of the recommended methods as a basis for estimating the creep-time response.

The expression in the form recommended by the ACI Committee 209, has been adopted by many investigators [21,28,64,65] with satisfactory results. In this study, the measured data on creep response will be used when available. In the absence of the long-term measurements, the ACI Committee 209 recommendations will be adopted.

2.1.3.2 Creep Under Variable Stress

The creep functions previously mentioned, represent the experimental data of concrete under a state of constant stress. In reality, under a variable arrangement of loading, stress in every part of the structure is changing, gradually or abruptly, with time. Although attempts have been made, with considerable success, to use a single creep function to predict creep under gradually varying sustained stress, rather poor results were obtained in the case of abruptly changing stresses. Several techniques have been proposed to handle this situation.

It is assumed that there is a creep function representing creep-time relation of concrete under a constant stress, and assuming that creep is proportional to the applied stress, several methods are available to estimate the amount of creep under time-dependent stress. They may be divided into three broad categories: a) Creep depends on the stress at the time of consideration only. b) Rate of creep depends on the stress at time of consideration, and c) Rate of creep depends on the complete history of the stress application. The following are the most commonly used methods.

2.1.3.2.1 The Effective Modulus Method

This is probably the simplest and most widely used method. It uses an elastic approach, taking into account creep effects, exclusive of shrinkage, by using the effective modulus instead of the normal modulus of elasticity. The effective modulus is a function of time and can be defined as:

$$(E_{eff})_t = (E_c)_t \,/\, (1 + C_t)$$

where

$(E_{eff})_t$ = Effective modulus of elasticity of concrete at time t

$(E_c)_t$ = Modulus of elasticity of concrete at time t

C_t = Creep coefficient at time t.

The effective modulus method is of the first category, creep at any time depends on stress at that instant only. Stress history is disregarded. Upon the removal of stress complete creep recovery is assumed, which is rarely the case for concrete. The method will overestimate creep under gradually increasing stress and underestimate creep under gradually decreasing stress [66]. Satisfactory results will be obtained for creep under approximately constant stress.

2.1.3.2.2 The Rate of Creep Method

Assuming that rate of creep at any age of concrete is independent of the time at which concrete is loaded, creep may be estimated as:

$$(\varepsilon_c)_{t_n} = \sum_{i=0}^{n} (f_c)_i \; (\Delta c_\varepsilon)_i$$

where

n = number of time increments in the interval of time

t_n = time at the end of time increment n

$(f_c)_i$ = concrete stress within time increment i

$(\Delta c_\varepsilon)_i = (c_\varepsilon)_{t_i} - (c_\varepsilon)_{t_{i-1}}$, specific creep increment in the time increment i

The method takes into account, to some extent, the history of the applied stress. Since the rate of creep in concrete decreases with the age of concrete, the method will underestimate the amount of creep due to stress applied at later ages. The rate of creep method, will underestimate creep under gradually increasing stresss and vice-versa. No creep recovery will be predicted upon the removal of load. Under constant stress, the method will give adequate accuracy.

2.1.3.2.3 The Superposition Method

The superposition method is of the third category, rate of creep depends on the complete history of the applied stress. According to Ross [66], the superposition hypothesis may be stated as: The strain produced in concrete at any time t by stress increment applied at time $t' < t$ is independent of the effects of any stresses applied either earlier or later than the time t'. The stress increments may be either positive or negative, assuming that creep in tension and compression are equal for equal stresses, which is approximately true for concrete. For the principle of superposition, it is not easy to write a general equation, as done for the rate of creep method, but a numerical solution for any case is not a complicated matter.

Several investigators have compared the accuracy of the creep predictions, using different methods of analysis. Ross [66] have compared, in their original forms, the effective modulus method, the rate of creep method, and the superposition method with the measurements of creep under gradually increasing and decreasing stresses, and under severely variable stresses. The effective modulus method gave the poorest results. The rate of creep method gave results comparable to the superposition method. The first one underestimated creep under gradually increasing stress and vice-versa, the latter gave errors in the opposite sense. For severely variable stresses, both methods estimated creep approximately the same magnitude as the experimental data. However, the lack of creep recovery in the rate of creep method, upon removal of the stress, led to the error in the general shape of the strain-time response curve. The trend of the strain-time response curve predicted by the superposition method agreed well with the data.

In the present study, both the rate of creep and the superposition methods are utilized, since the effective modulus method does not completely suit the needs of the problems analyzed.

2.1.3.3 Shrinkage

As in the creep-time relationship, shrinkage increases with time at a decreasing rate, providing that there is no change in ambient conditions. Shrinkage also tends to approach a finite value. While the final value of shrinkage of concrete depends on many factors, i.e. the composition of concrete, time of exposure to the atmosphere conditions, size and shape of the specimen, etc, the shape of the shrinkage-time curves for various concretes under different conditions are remarkably similar. It is then convinient to express the shrinkage-time relationship as a product of the ultimate shrinkage and a function of time, as done for the case of creep.

Although shrinkage has been noticed and studied from as earlier as the beginning of the century [(67)], Ross [(66)], was probably the first one to express the shrinkage-time relationship as a mathematical function. Since then, several investigators have proposed many different models and mathematical functions to represent the shrinkage-time relationship of concrete, and used with satisfactory results.

Based on the work by Branson and Christiason [(64)], the ACI Committee 209 [(63)] recommended the following expression to predict shrinkage:

$$(\varepsilon_{sh})_t = (\varepsilon_{sh})_u \; t^b / (a + t^b)$$

For normal, sand-lightweight and all-lightweight concretes, both moist and steamed cured, and using type I and type III cements, the constants a and b, were found to range from 20 to 150 and from 0.9 to 1.1 respectively. The ultimate shrinkage $(\varepsilon_{sh})_u$ was found to range from - 415.10^{6} in/in to - 1070.10^{6} in/in.

Standard shrinkage equations are suggested. The equations are for concrete with 4 in or less slump, placed in ambient relative humidity of 40 percent with minimum member thickness of 6 in or less.

Shrinkage of concrete after 7 days of moist curing -

$$(\varepsilon_{sh})_t = (\varepsilon_{sh})_u \; t / (35 + t)$$

Shrinkage of concrete after 1 to 3 days of steam curing -

$$(\varepsilon_{sh})_t = (\varepsilon_{sh})_u \; t / (55 + t)$$

The suggested average value for $(\varepsilon_{sh})_u$ is - 800.10^{-6} in/in for moist cured concrete and - 730.10 in/in, for steam cured concrete. The following corrections are used for concrete with other conditions:
Shrinkage correction factor for ambient humidity greater then 40 percent

$$CS_h = 1.4 - 0.01\,H \quad , \quad 40 < H < 80$$

$$CS_h = 3.0 - 0.03\,H \quad , \quad 80 < H < 100$$

Shrinkage correction factor for member thickness -

$$CS_t = 1.23 - 0.038\,T \quad , \quad \text{for 1 yr. of drying}$$

$$CS_t = 1.17 - 0.029\ T \quad , \quad \text{for ultimate value}$$

Shrinkage correction factor for consistency of concrete -

$$CS_s = 0.89 - 0.041\ S \quad , \quad \text{where } S = \text{slump in in}$$

Shrinkage correction factor for cement content of concrete -

$$CS_b = 0.75 + 0.034\ B$$

where B is the number of 94 lb sacks of cement per cubic yard.

Shrinkage correction factor for aggregate content of concrete -

$$CS_f = 0.3 + 0.014\ F \quad , F < 50$$

$$CS_f = 0.9 + 0.002\ F \quad , F > 50$$

where F is the percent of fine aggregate by weight.

Shrinkage correction factor for air content -

$$CS_a = 0.95 + 0.008\ A$$

where A is the air content in percent.

For shrinkage of concrete moist cured one day, a correction factor of 1.2 is used. A linear interpolation may be used between 1.2 at 1 day and 1.0 at 7 days.

The PCI Committee on Prestress Losses (23) recommended equations to calculate prestress losses due to shrinkage. By dividing the values of the prestress loss due to shrinkage by the modulus of elasticity of the prestressing steel, (28.10^6 psi), those values may be written in terms of the equivalent shrinkage strain as:

$$(\varepsilon_{sh})_t = (\varepsilon_{sh})_u \ CS_t \ (g_s)_t$$

where

$(\varepsilon_{sh})_t$ = Shrinkage strain at time t

$(\varepsilon_{sh})_u$ = Basic value for ultimate shrinkage

CS_t = Correction factor for shape and size of member

$(g_g)_t$ = Function representing the development of shrinkage with time, evaluated at time t

The basic value for ultimate shrinkage $(\varepsilon_{sh})_u$ may be written as:

For normal weight concrete -

$$(\varepsilon_{sh})_u = - 9.643 \cdot 10^{-6} + 1.071 \cdot 10^{-10} \; E_c < - 4.29 \cdot 10^{-6}$$

For lightweight concrete -

$$(\varepsilon_{sh})_u = - 1.464 \cdot 10^{-6} + 3.571 \cdot 10^{-10} \; E_c < - 4.29 \cdot 10^{-6}$$

The values are in in/in. The correction factor for the shape and size of the member CS_t and the shrinkage-time function, (g_s) can be found in tables and curves shown in the PCI publication (23) .

The expressions in the form proposed by the ACI Committee 209, have been used by several investigators (49,64,65) with satisfactory results. In the present study, the measured values of ultimate shrinkage, from the comparable specimens, will be used when available. In the absence of such experimental data, the ACI committee 209 recommendations will be used.

2.1.3.4 Aging

Concrete under normal ambient conditions gains strength with age because of further hydration of the cement. A study of fifty year properties of concrete by Washa and Wendt (68) , showed the increase in strength of concrete to reach a peak value at the ages of about 10 to 50 years, depending on the storage conditions and the type of cement uesd, and showed strength decrease thereafter. The average increase in compression strength at the age of fifty years is about 10 to 40 percent of the strength of the comparable specimens at the age of 28 days. Although the increase in strength is usualy neglected in design, for more accuracy, the effect will be included in the present study.

Compressive strength tests of concrete cylinders are usually made at the age of 7 or 28 days. Several investigators have attempted, almost all of them with experimental data, to relate the strength of concrete at a later age to the strength at a standard early age. The relationship depends on many factors, such as water-cement ratio, mix proportion, qualities of cement, curing conditions, and cross-sectional shape. For a particular mix, age strength relationship of concrete may be expressed as a function of the age of concrete and curing conditions. Several empirical expressions have been proposed by many investigators. In this study, the ACI Committee 209 recommendations (63) will be adopted.

Based on the work by Branson and Christiason (64), the ACI Committee 209 recommends the use of a hyperbolic function for the prediction of the aging effect on the strength of concrete

$$(f'_c)_t = (f'_c)_{28} \; t / (a + b t)$$

From the measurement of some 88 specimens, of normal weight, sand-lightweight, and all-lightweight concrete, using both moist curing and steam curing, and type I and type III cements, the values of the constant a are found to range from 0.5 to 9.25, and the constant b from

0.67 to 0.98.

The following values have been suggested for different types of cement and curing conditions.

Moist cured concrete and type I cement -

$$(f'_c)_t = (f'_c)_{28} \ t / (4.00 + 0.85 t)$$

Moist cured concrete and type III cement -

$$(f'_c)_t = (f'_c)_{28} \ t / (2.30 + 0.92 t)$$

Steamed cured concrete and type I cement -

$$(f'_c)_t = (f'_c)_{28} \ t / (1.00 + 0.95 t)$$

Steamed cured concrete and type III cement -

$$(f'_c)_t = (f'_c)_{28} \ t / (0.70 + 0.98 t)$$

The stress-strain curves of concrete, as previously discussed, can be expressed as a function of the cylinder compressive strength of concrete, f'_c . For consistency, every key value should be estimated from the strength of concrete at the time of consideration. Without redefining the general shape of the curve, a stress at any strain, at different ages, may be found from modified curves taking into account the aging factor $(f'_c)_t / (f'_c)_{28}$.

The factors are applied in such a way that the initial and instantaneous modulus, and the stress and maximum compressive strength of the modified curve will be the same as those of the actual curve at that age. The strain limits, however, will not be modified in the new curves.

2.2 Reinforcement Steel

2.2.1 Constitutive Relationship for Loading and Unloading

Instantaneous stress-strain relationship of steel is ususlly obtained from uniaxial tensile tests of a sample taken from the steel of interest. Unlike concrete, the tensile stress-strain curve of steel can be obtained up to the ultimate strain of the material, with relative ease. The stress-strain curve is commonly assumed to have symmetry about the origin, i.e. the stress-strain response in compression is the same as in tension. Since there is no aging effect in steel, the stress-strain relationship can be used to represent the instantaneous tensile and compressive response without any modification.

As commonly used in design and analysis the stress-strain relationship of mild steel may be approximated by a perfect elasto-plastic, bilinear curve, as shown in Fig. 2.5, with results presenting a very acceptable degree of accuracy.

For the case of unloading and reloading of the reinforcement steel, it is well known that this material presents the effect of hysteresis, although much less pronounced then in the case of concrete. However, an usual simplification is to assume that the unloading and reloading curves follow straight lines, parallel to the initial loading curve, inscribed within the envelope, monotonically obtained stress-strain relationship [58,69].

In the present study, both simplifications have been assumed, and the adopted stress-strain relationship for loading, unloading and reloading is sketched in Fig. 2.5.

2.3 Prestressing Steel

2.3.1 Constitutive Relationship for Loading and Unloading

As will be seen in a later chapter, the approach used in this study requires stresses in the member to be obtained from the strains. The problem is less complicated in the case of steel, since there is no change in strain of steel due to aging and moisture content. The total strain in steel may be considered as the sum of instantaneous and relaxation strains. Relaxation will be defined as the time-dependent loss of stress of steel under relatively constant strain. Relaxation strain will be defined as the reduction in strain that gives the reduction in stress equal to relaxation, utilizing the instantaneous stress-strain relationship of the material.

As with the case of mild steel, the instantaneous stress-strain relationship for prestressing steel is obtained from uniaxial tensile tests. This material, however, presents a somewhat different stress-strain curve, in the sense that there is no well-defined yield point and it shows a comparatively smaller ductility range.

A simplified tri-linear stress-strain curve seems to be a reasonable approximation for the stress-strain relationship under monotonic tensile stressing of prestressing steel, and it has been adopted in this study. As the case of concrete and reinforcing steel, the stress-strain relationships for unloading and reloading have been assumed as straight lines parallel to the initial loading curve. The assumed and simplified stress-strain relationship for the prestressing steel, in tension, for loading, unloading and reloading, is shown in Fig. 2.6.

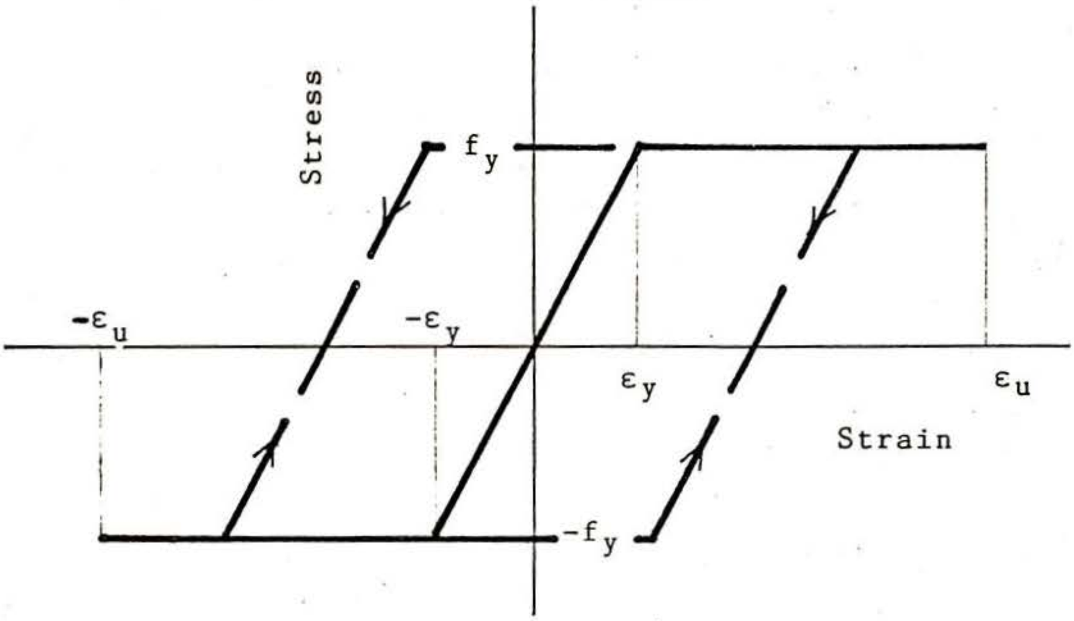


Fig 2.5 - Elasto-plastic stress-strain relationship for reinforcing steel.

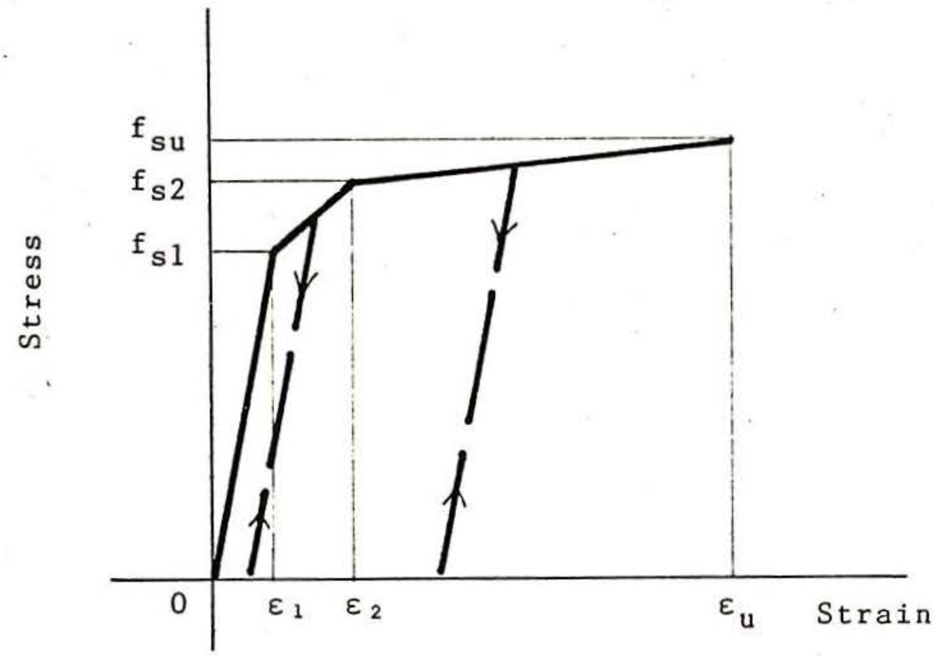


Fig 2.6 - Tri-linear stress-strain relationship for prestressing steel.

2.3.2 Relaxation Under Constant Strain

For prestressed concrete members, the relaxation of steel is of great concern. Initially the stress in prestressing steel is as high as 0.8 of its ultimate strength. At this level, relaxation over a long period of time may be as high as 15 percent of its initial stress [70]. Although relaxation does not decrease the flexural strength of a bonded prestressed member, it affects the servicibility of the member.

Relaxation is a function of type of steel, initial stress-strength ratio, and temperature. It is also affected to some extent by rate of loading. High temperature may increase long-term relaxation several times, but under ordinary ambient conditions the temperature effect is negligible. The effect of rate of loading may also be neglected, since it has been shown that the rate of loading has an effect at the initial stress-strength ratio of about 0.8 to 0.94 [70], well above the stress level that would occur under service load.

Many papers have been published reporting relaxation test results and some investigators have attempted to describe relaxation as mathematical functions, like power functions, quadratic functions and logarithmic functions.

The PCI Committee on Prestress Losses [23] recommended the relaxation expression from Magura, et al [71], with the destinction between stress-relieved and low-relaxation steels. The following expressions are recommended:

For stress relieved steel -

$$(f_r)_{t,t_1} = (f_s)_t - (f_s)_{t_1}$$

$$= (f_s)_t \, [(\log 24t - \log 24t_1)/ 10][(f_s)_t / f_{sy} - 0.55]$$

$$(f_s)_t / f_{sy} > 0.60 \quad , \quad f_{sy} = 0.85 f_{su}$$

For low-relaxation steel -

$$(f_r)_{t,t_1} = (f_s)_t - (f_s)_{t_1}$$

$$= (f_s)_t \, [(\log 24t - \log 24t_1)/ 45][(f_s)_t / f_{sy} - 0.55]$$

$$(f_s)_t / f_{sy} > 0.60 \quad , \quad f_{sy} = 0.90 f_{su}$$

where

$(f_s)_t$ = Stress in prestressing steel at time t in days

$(f_r)_{t,t_1}$ = Relaxation stress of prestressing steel between times t and t_1 in days

f_{sy} = Specified yield stress of steel

f_{su} = Ultimate strength of steel

In this study the above expressions are used.

2.3.3 Relaxation Under Variable Strain

Strain variation in prestressing steel is not as severe as stress variations in concrete and reinforcing steel. In an ordinary prestressed concrete member, the change in strain of prestressing steel under service load rarely exceeds 20 percent of the initial strain. Consequently, not much attention had been paid to relaxation under variable strain. Most of the relaxation data were obtained under constant strain, and the relaxation functions previously mentioned were based on this type of data. Under varying strain, however, Ghali and Trevino (16) have shown that the relaxation in prestressed concrete steel is of smaller magnitude than the intrinsic relaxation which occurs when a tendon is stretched with constant strain, and it is assumed [23] that a method equivalent to the rate of creep method is adequate to handle the situation of variable strain. It was decided then, in the present study, to use a method equivalent to the rate of creep method in determining the relaxation of prestressing steel under variable strain.

2.4 Elastomeric Bearing Pads

Bearing pads are widely used in all kinds of precast structures. Their main purpose is to distribute vertical loads over the bearing area and to reduce force build-up at the connections by permiting some small displacements and rotations. In the case of bridge girders, especially for accommodating the temperature variation, their use has proven beneficial and often may be necessary for satisfactory performance.

Several different materials and compositions have been used for the manufacturing of structural bearing pads such as AASHTO-grade chloroprene pads, made of pure neoprene and recently also mixed with reinforcing fibers; cotton-duck fabric reinforced pads, used for high compressive stress; tempered hardboard pads, used in hollow core slabs; TFE (trade name Teflon) coated pads, often used for large horizontal movements. For bridge girders, chloroprene pads laminated with alternated layers of bonded steel or fiberglass are widely used.

The design of such pads is influenced by many factors [18], like material used, hardness characteristics, shear modulus, ambient temperature and relative humidity variation, amount of pressure to be transmitted and overall characteristics of the structure where the pad is to be used. Not many publications are found presenting experimental data from tests on bearing pads (72), and few concern design recommendations for such connections (18,72,73).

The PCI (18) based on the work from Iverson, et al (73), presents some recommendations for the selection and design of elastomeric bearing pads. Refering to Fig. 2.7, the compressive stress f which depends on the hardness characteristic of the material and ambient temperature, is limitted to a maximum of 1000 psi.

$$f = V / b\ w \leqslant 1000 \text{ psi}$$

The maximum allowed compressive stress, for 15 percent strain, is obtained according to the shape factor S,

$$S = w\ b / 2\ t\ (\ w + b\ )$$

and the maximum unfactored shear force N is obtained from

$$N = \Delta\ w\ b\ G_t / t$$

where

f = Unfactored compressive stress, in psi

V = Unfactored vertical reaction, in lb

N = Unfactored horizontal reaction, in lb

W = Dimention parallel to the beam span, in in

b = Dimension perpendicular to the beam span, in in

t = Total thickness of the pad, in in

G_t = Long-term shear modulus, in psi

= G / 2

G = Shear modulus

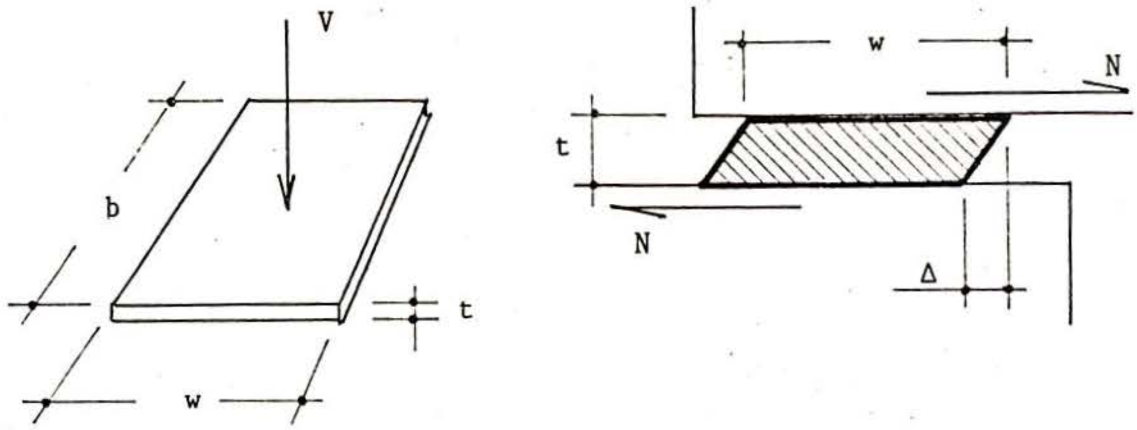


Fig 2.7 - Bearing pads.

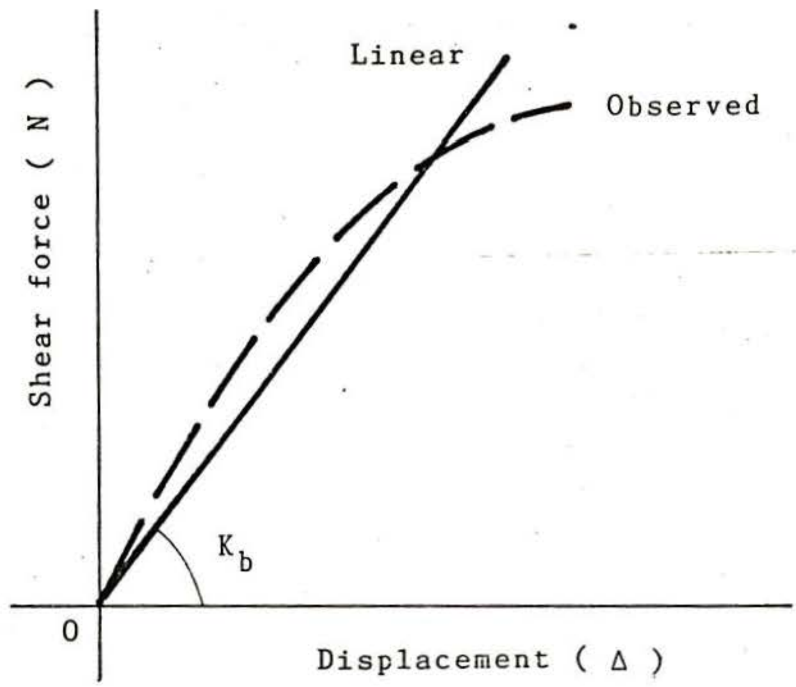


Fig 2.8 - Linear shear-deformation relationship for bearing pads.

Δ = Shear deformation, in in

The shear force-deformation relationship (N - Δ) presented by those pads, as shown in the work by Vinje (72) , is nonlinear. Assuming that they are properly designed and working within the service load range of the structure, a linear relationship may be assumed, neglecting the nonlinear effect on the value of the horizontal reaction N. In the present study, a linear force-deformation relationship as shown in Fig. 2.8 is assumed for modeling the support bearing pads, and their stiffness coefficient is obtained as:

$$N = K_b \ \Delta$$

$$K_b = G_t \ A \ / \ t$$

where

N = Unfactored horizontal reaction, in lb

Δ = Maximum expected shear deformation in in

A = Contact area of the bearing pad, in in^2

t = Total pad thickness, in in

G_t = Long-term shear modulus, in psi

K_b = Shear stiffness of the bearing pad, in lb.in^3

Where experimental data for the bearing shear stiffness is available, this value will be used. In the absence of such data, the value obtained as shown above will be assumed.

3. METHOD OF ANALYSIS

3.1 Introduction

A general composite beam may have a variable cross-section along its length. Its constituent members may be simply supported over one span or continuous over two or more spans. Continuity may be fully obtained by casting a continuous girder and deck or by connecting individual one-span girders to one another through diaphragms over the intermediate supports. Girders may be, otherwise, indirectly connected to its companion by casting a continuous deck slab. Loads and restraints may be applied in any of the three directions, i.e. the member axial direction, the transverse direction and the rotational direction. Applied loads may be concentrated or linearly distributed. The beam may be of reinforced concrete, prestressed concrete or steel. The amount of reinforcing steel in various layers and the magnitude and location of the prestressing force may also vary along the length. Response analysis of such a structure may encounter a considerable amount of complexity when nonlinear and time-dependent effects are also introduced and analytical closed-form solutions are not possible. A numerical solution, however, seems to be a suitable approach.

Many numerical solutions for the analysis of beams are found in the literature. Some, using the finite element technique, are adequate for reinforced concrete members [28,29,30,31,32,33] and others based on the discrete element method are applied to prestressed concrete members [34,35,36,37,38]. However, none was found broad enough as to suit the needs of the problem under consideration, as discussed in Chapter 1.

In this chapter a method of analysis based on the finite element techinique is presented. Two elements are formulated and used for modeling beams and deck-continuity among the beams. Beam elements may be used for the analysis of either steel, reinforced concrete, prestressed concrete or composite steel-concrete members. Connection elements, however, are used only for modeling reinforced concrete deck slabs. Both instantaneous and time-dependent responses of a beam may be obtained by the proposed solution. Linear and nonlinear ranges of behavior are captured in one single analysis where loading and restraints are predefined according to the actual stages of construction.

3.2 Beam Element

3.2.1 Conventional Beam Element

The formulation of a conventional beam element is well known and can be found in many books on finite element methods. For purpose of illustration, however, it is shown in this section and used for comparison with the formulation of the isoparametric beam element adopted in this thesis.

Let us for the time being consider a two-noded three degrees-of-freedom per node beam element as shown in Fig. 3.1, having a cross-section with a vertical plane of symmetry. The behavior of such an element relies on the three basic assumptions that follow:

(a) The direct strains in the transverse direction y are negligibly small.

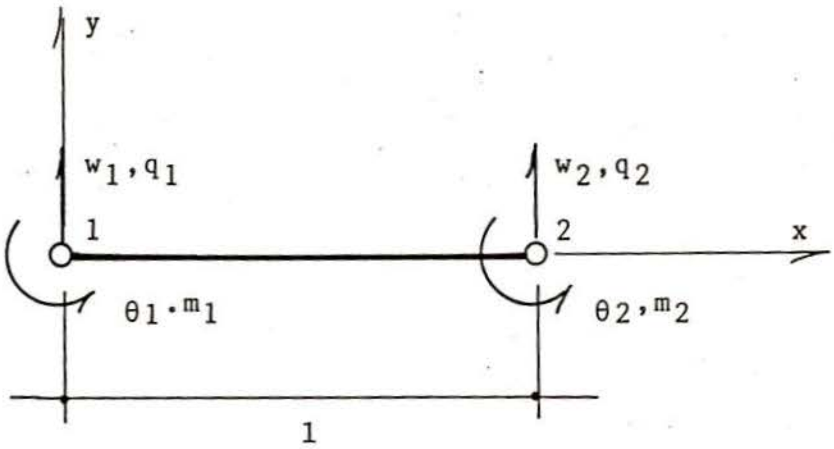


Fig 3.1 - Conventional beam element.

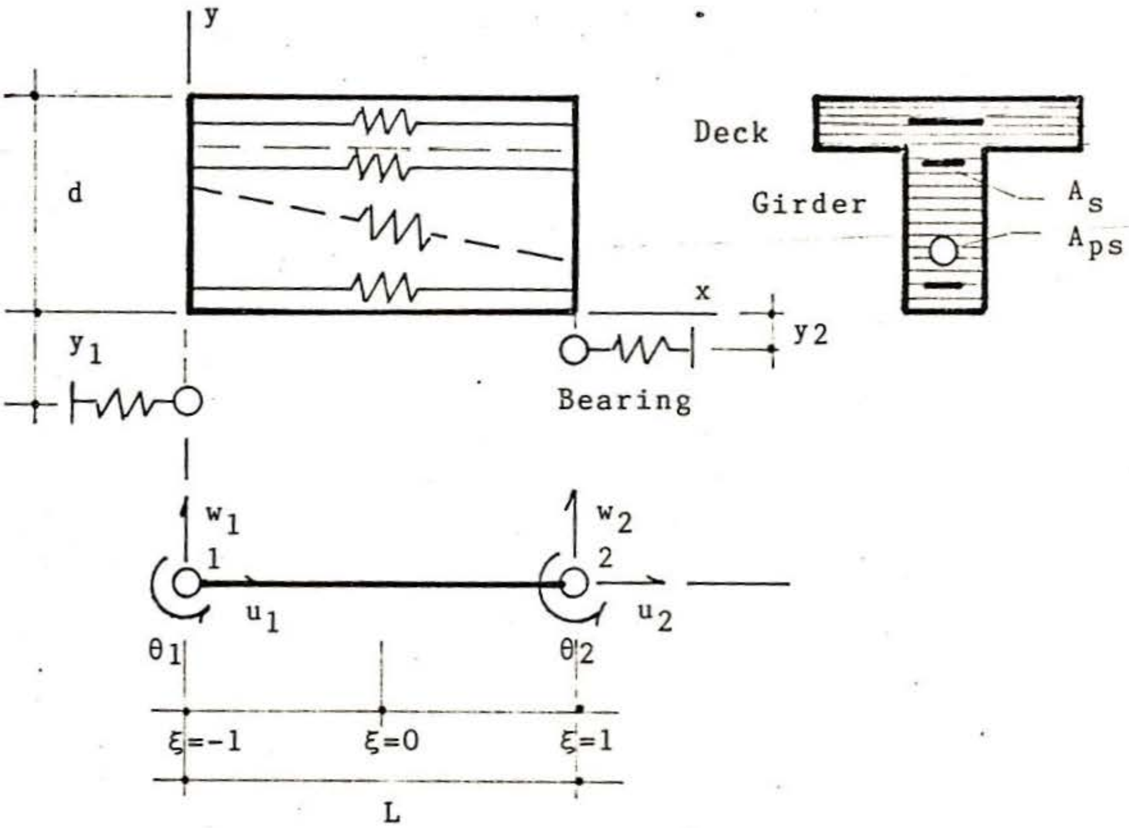


Fig 3.2 - Isoparametric beam element.

(b) A plane cross-section normal to the longitudinal axis of the beam remains plane after the beam deforms. Such is true when the transverse shear strain is constant through the thickness of the beam.

(c) A normal to the longitudinal axis of the beam, in the vertical plane of symmetry, remains normal to the longitudinal axis after deformation. It is thus implied that not only assumption (b) holds but that the transverse shear deformation is negligibly small, $\gamma_{xy}=0$. Assumption (a) above leads to the following.

$$\frac{\partial w}{\partial y} = 0 \tag{3.1}$$

Accordingly the transverse displacement w is a function of the coordinate x alone. From assumptions (b) and (c) one have

$$\frac{\partial u}{\partial y} = - \frac{dw}{dx} \tag{3.2}$$

Since w is not a function of y, eq. 3.2 may be integrated to give.

$$u = - \left(\frac{dw}{dx} \right) y + u_o (x) \tag{3.3}$$

in which $u_o(x)$ is the longitudinal displacement in the direction of the reference axis x. The longitudinal strain ε_x is obtained by taking the derivative of the longitudinal displacement u in the equation above, leading to

$$\varepsilon_x = - \left(\frac{d^2w}{dx^2} \right) y + \frac{du_o}{dx} \tag{3.4}$$

or

$$\varepsilon_x = \chi y + \varepsilon_{xo} , \quad \chi = - \frac{d^2w}{dx^2} , \quad \varepsilon_{xo} = \frac{du_o}{dx}$$

The beam is in a state of plane stress. For a linear, elastic, isotropic material the stress-strain relationship is given by

$$\begin{Bmatrix} \sigma_x \\ \sigma_y \end{Bmatrix} = \frac{E}{1 - \nu^2} \begin{bmatrix} 1 & \nu \\ \nu & 1 \end{bmatrix} \begin{Bmatrix} \varepsilon_x \\ \varepsilon_y \end{Bmatrix} \qquad 3.5$$

It is known that the direct stress in the transverse direction σ_y, is negligibly small. Therefore, we assume $\sigma_y=0$ which with eq. 3.5 gives

$$\varepsilon_y = - \nu \, \varepsilon_x \qquad 3.6$$

and

$$\sigma_x = E \, \varepsilon_x \qquad 3.7$$

In developing the strain-displacement relationship above we have assumed $\varepsilon_y=0$, which is inconsistent with the assumption $\sigma_y=0$ made in the stress-strain relationship. This apparent inconsistency can be explained as follows. Neither ε_y nor σ_y are exactly equal to zero, but both are quite small. In using these assumptions, however, we should avoid using the condition $\varepsilon_y=0$ for evaluating $\sigma_y[=\nu E\varepsilon_x/(1-\nu^2)]$, and using the condition $\sigma_y=0$ for evaluating $\varepsilon_y[=-\varepsilon_x]$. A further justification of the above assumptions is that they lead to a beam theory which adequately agrees with the observed behavior.

According to eqs. 3.4 and 3.7, the longitudinal stress σ_x is written as

$$\sigma_x = E \, \chi y + E \, \varepsilon_{xo} \qquad 3.8$$

and a normal force F, in the longitudinal direction, can be obtained by integrating the above stresses over the element cross-section as

$$F = \int \sigma_x \, d\,A = X \int E\,y\,d\,A + \varepsilon_o \int E\,d\,A \qquad 3.9$$

Taking the reference axis of the above integration as the cross-section neutral axis and assuming that no axial force F is applied to the element, eq. 3.10 follows.

$$\varepsilon_{xo} = \frac{du_o}{dx} = 0 \qquad 3.10$$

Assuming no rigid body motion is present, displacement $u_o = 0$. From assumption (a) it is concluded that $w = w\ (x)$. In the conventional beam element the transversal displacement field is represented by a cubic polynomial in x.

$$w = a + bx + cx^2 + dx^3 = (\ x\ )\ \{\ a\ \}$$

$$3.11$$

$$(\ x\ ) = (1\ x\ x^2\ x^3)\ , \quad \{\ a\ \}^T = (\ a\ b\ c\ d\ )$$

The nodal displacements at nodes 1 and 2, vertical displacements w_1 and w_2 and rotations θ_1 and θ_2 respectively, may be expressed in terms of the coefficients of the assumed polynomial and the length of the element as

$$\{\ d\ \} = [\ A\ ]\ \{\ a\ \}$$

or $\qquad 3.12$

$$\begin{Bmatrix} w_1 \\ \theta_1 \\ w_2 \\ \theta_2 \end{Bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 1 & 1 & 1^2 & 1^3 \\ 0 & 1 & 21 & 31 \end{bmatrix} \begin{Bmatrix} a \\ b \\ c \\ d \end{Bmatrix}$$

In other words, the coefficients a, b, c and d of the polynomial defining the vertical displacement at any point within the element may be obtained in terms of the nodal displacements as

$$
\begin{aligned}
a &= w_1 \\
b &= \theta_1 \\
c &= [\ 3\ (\ w_2 - w_1\ ) - 2l\ (\ \theta_1 + \theta_2\ )\ ]\ /\ l^2 \\
d &= [\ -2\ (\ w_2 - w_1\ ) + l\ (\ \theta_1 + \theta_2\ )\ ]\ /\ l^3
\end{aligned} \qquad 3.13
$$

For obtainig the vertical displacements w in terms of the nodal displacements, a set of shape functions N are defined as

$$w = (\ N\ )\ \{\ d\ \}\ , \qquad N = (\ x\ )\ [\ A\ ]^{-1}$$

or

$$w = \frac{1}{l^3} \begin{Bmatrix} l^3 - 3\ l\ x^2 + 2\ x^3 \\ l^3\ x - 2\ l^2\ x^2 + l\ x^3 \\ 3\ l\ x^2 - 2\ x^3 \\ -l^2\ x^2 + l\ x^3 \end{Bmatrix}^T \begin{Bmatrix} w_1 \\ \theta_1 \\ w_2 \\ \theta_2 \end{Bmatrix} \qquad 3.14$$

Rotations θ , defined as the incremental rate of the vertical displacements w with respect to the horizontal coordinate x, are obtained by differentiating the shape functions (N) in eq. 3.14 as

$$\theta = \frac{d}{dx}\ (\ N\ )\ \{\ d\ \} = (\ N'\ )\ \{\ d\ \}$$

or

$$\theta = \frac{1}{l^3} \begin{Bmatrix} -6\,l\,x + 6\,x^2 \\ l^3 - 4\,l^2\,x + 3\,l\,x^2 \\ 6\,l\,x - 6\,x^2 \\ -2\,l^2\,x + 3\,l\,x^2 \end{Bmatrix}^T \begin{Bmatrix} w_1 \\ \theta_1 \\ w_2 \\ \theta_2 \end{Bmatrix} \qquad 3.15$$

Curvatures X are obtained as the second derivative of the vertical displacements w, or the incremental rate of the rotations θ with respect to the axial coordinate x as

$$X = \frac{d^2w}{dx^2} = -\frac{M}{EI}$$

or

$$X = -\frac{d^2}{dx^2}\,(\,N\,)\,\{\,d\,\} = (\,N''\,)\,\{\,d\,\} = (\,B\,)\,\{\,d\,\} \qquad 3.16$$

or

$$X = \frac{1}{l^3} \begin{Bmatrix} -6\,l + 12\,x \\ -4\,l^2 + 6\,l\,x \\ 6\,l - 12\,x \\ -2\,l^2 + 6\,l\,x \end{Bmatrix}^T \begin{Bmatrix} w_1 \\ \theta_1 \\ w_2 \\ \theta_2 \end{Bmatrix}$$

Normal strains ε_x, which vary linearly through the depth of the element according to eqs. 3.7 and 3.10, may be obtained from the curvature X as

$$\varepsilon_x = Xy$$

or 3.17

$$\varepsilon_x = (\,B\,)\,\{\,d\,\}\,y$$

Observing the linear stress-strain relationship assumed, shown in eq. 3.7, the normal stresses σ_x are derived from the normal strains ε_x as

$$\sigma_x = E \, (B) \, \{ d \} \, y \qquad 3.18$$

By applying to an element a set of arbitrary virtual displacements $\{\delta d\}$, normal strains $\delta\varepsilon_x$ are therefore developed and may be expressed as

$$\delta\varepsilon_x = (B) \, \{ \delta d \} \, y \qquad 3.19$$

The internal work done by the stresses σ_x may then be obtained as

$$\delta W_i = \int_v \sigma_x \, \delta\varepsilon_x \, dv$$

or

$$\delta W = \int_v \sigma_x \, (B) \, \{ \delta d \} \, y \, dv \qquad 3.20$$

Under the action of the external nodal forces $\{f\}$ and the applier virtual displacements $\{\delta d\}$, some external work is performed and may be expressed as

$$\delta W_e = \{ f \} \, \{ \delta d \}$$

or

$$\delta W_e = (q_1 \; m_1 \; q_2 \; m_2)^T \begin{Bmatrix} w_1 \\ \theta_1 \\ w_2 \\ \theta_2 \end{Bmatrix} \qquad 3.21$$

As an equilibrium requirement, both internal and external work must be the same. Since $\{\delta d\}$ is arbitrary eqs. 3.20 and 3.21 give

$$\{ f \} = \int_V \sigma_x (B) y \, dv \qquad 3.22$$

By substituting eq. 3.18 into eq. 3.22

$$\{ f \} = \int_V E (B) \{ d \} (B) y^2 \, dv$$

or 3.23

$$\{ f \} = [\int_V E (B)^T (B) y^2 \, dv] \{ d \}$$

The element stiffness matrix [k], defined as the relation between applied forces {f} and the nodal displacements {d} is then expressed as

$$[k] = \int_V E (B)^T (B) y^2 \, dv$$

or 3.24

$$[k] = \int_l EI (B)^T (B) \, dx$$

When stiffness EI is constant throughout the element the stiffness matrix may be expressed as

$$[k] = EI \int_l (B)^T (B) \, dx \qquad 3.25$$

The coefficients of the (4x4) stiffness matrix are obtained by substituting (B), as shown in eq. 3.16, into eq. 3.25 and performing the linear integration as shown for the first coefficient k11

$$k_{II} = EI \int_0^l \frac{1}{l^2} (- 6 l + 12 x)^2 \, dx = \frac{12 EI}{l^3} \qquad 3.26$$

By applying an equivalent procedure, the remaining coefficients may be obtained and the final stiffness matrix is shown as

$$[\ k\ ] = \begin{bmatrix} 12 & 6l & -12 & 6l \\ 6l & 4l^2 & -6l & 2l^2 \\ -12 & -6l & 12 & -6l \\ 6l & 2l^2 & -6l & 4l^2 \end{bmatrix} \frac{EI}{l^3} \qquad 3.27$$

The derivation shown above models the behavior of a two-noded conventional beam element with two degrees-of-freedom per node, as shown in Fig. 3.1. Its formulation considers a beam element without any axial force and deformations. It is costumary to include a horizontal degree-of-freedom at the two nodes if the axial forces are present. If the reference axis coincides with the neutral axis of the beam, as previously assumed, it can be shown that the axial and bending stiffness terms are mutually uncoupled. In order to apply support conditions and axial forces, which may not be at the neutral axis, a linear transformation may be used.

$$u_{(\text{ at } y\ )} = u_{(\text{ at neutral axis })} - y\theta \qquad 3.28$$

This, however, presents a problem as pointed out by Gupta and Ma (74). The axial displacement along the reference axis varies linearly with the x coordinate. On the other hand, the transverse displacement is cubic in x and consequently the rotational displacement is quadratic. According to eq. 3.28, u for any nonzero value of y is therefore quadratic. This creates an inconsistency, and renders the element unfit for cases when the transformation required in eq. 3.28 needs to be applied. Therefore, the conventional beam element has been discarded for use in the present study.

3.2.2 Isoparametric Beam Element

Since their first appearance, in the sixties [75], isoparametric beam elements have shown remarkable versatility, they have proven effective in two- and three-dimensional structural analyses and non structural applications as well. They are named isoparametric for their property of expressing the displacement field and the coordinate transformation through the same (ISO) set of interpolation functions (parameters), commonly known as shape functions. Their general formulation can be found in most finite element books [76,77,78]. Here, we will restrict ourselves to presenting the formulation of the one-dimentional beam element adopted.

As in the conventional beam element, here too, we assume that the direct strains in the transverse direction y are negligibly small and that the plane cross-section normal to the longitudinal axis of the beam remains plane after the beam deforms ($\gamma_{xy}=$ constant along y). Unlike the conventional beam element, normal to the longitudinal axis of the beam, in the vertical plane of symmetry, are not assumed to remain normal after deformation. Further, the direct stress in the normal direction is assumed to be negligibly small, giving $\sigma_x=E\varepsilon_x$, as in the conventional beam element.

Referring to Fig. 3.2, taking u_i, w_i and θ_i , i = 1,2 , as the nodal degrees-of-freedom in the x direction, y direction and rotational direction respectively, the displacements at any point within the element can be expressed in terms of the shape functions as

$$u_{(y)} = \Sigma_i N_i u_i - y \Sigma_i N_i \theta_i$$

$$w = \Sigma_i N_i w_i \qquad 3.29$$

$$\theta = \frac{\partial u}{\partial y} = - \Sigma_i N_i \theta_i$$

The nodal coordinates can as well define the global coordinates at a point in the element, through the use of the same shape functions as

$$x = \Sigma_i N_i x_i \qquad 3.30$$

The interpolation or shape functions are defined in terms of the local coordinate ζ as

$$(N) = (N_1 \; N_2) = \left(\frac{1 - \xi}{2} \;\; \frac{1 + \xi}{2} \right) \qquad 3.31$$

The strain field is obtained as the first derivative of the displacements and also expressed in terms of the shape functions appear as

$$\varepsilon_x = \frac{\partial u}{\partial x} = \Sigma_i \frac{\partial N_i}{\partial x} u_i - y \Sigma_i \frac{\partial N_i}{\partial x} \theta_i$$

$$\varepsilon_y = \frac{\partial w}{\partial y} = \Sigma_i \frac{\partial N_i}{\partial y} w_i = 0 \qquad 3.32$$

$$\gamma_{xy} = \frac{\partial u}{\partial y} + \frac{\partial w}{\partial x} = - \Sigma_i N_i \theta_i + \Sigma_i \frac{\partial N_i}{\partial x} w_i$$

which in matrix notation leads to the definition of the [B] matrix as follows

$$\begin{Bmatrix} \varepsilon_x \\ \\ \gamma_{xy} \end{Bmatrix} = \Sigma_i \begin{bmatrix} \frac{\partial N_i}{\partial x} & 0 & -y\frac{\partial N_i}{\partial x} \\ \\ 0 & \frac{\partial N_i}{\partial x} & -N_i \end{bmatrix} \begin{Bmatrix} u_i \\ w_i \\ \theta_i \end{Bmatrix} \qquad 3.33$$

or

$$\{ \varepsilon \} = [B] \{ d \}$$

from which ζ is deleted because it is assumed to be zero. The nodal displacement vector consists of nodal degrees-of-freedom and is given by

$$\{ d \}^T = (u_1 \; w_1 \; \theta_1 \; u_2 \; w_2 \; \theta_2) \qquad 3.34$$

The shape functions are expressed in terms of the local coordinate ζ, so the derivation chain rule is invoked

$$\frac{\partial N_i}{\partial x} = \frac{\partial N_i}{\partial \xi}\frac{\partial \xi}{\partial x}$$

$$3.35$$

$$\frac{\partial x}{\partial \xi} = \Sigma_i \frac{\partial N_i}{\partial \xi} x_i = \left(\frac{\partial N_1}{\partial \xi} \; \frac{\partial N_2}{\partial \xi} \right) \begin{Bmatrix} x_1 \\ x_2 \end{Bmatrix}$$

and the scale factor between the two coordinate systems is defined as

$$\frac{\partial \xi}{\partial x} = \frac{2}{l} \qquad 3.36$$

The [B] matrix is then obtained as

$$[\,B\,] = \begin{bmatrix} -\frac{1}{l} & 0 & \frac{y}{l} & \frac{1}{l} & 0 & -\frac{y}{l} \\ \\ 0 & -\frac{1}{l} & -\frac{1-\xi}{2} & 0 & \frac{1}{l} & -\frac{1+\xi}{2} \end{bmatrix} \qquad 3.37$$

According to eq. 3.37 the transverse shear strain γ_{xy} varies linearly with ζ and therefore with x. The direct strain ε_x does not vary with ζ or x, which would be caused by a state of constant moment and axial force. The shear strain distribution is inconsistent with the moment distribution and is known to render the element stiffness matrix too stiff in shear (79). The spurious shear strains and stresses have been called parasitic and the effect on the element stiffness matrix shear-locking. It can be shown that eq. 3.33 evaluates the shear strain accurately at $\zeta = 0$, which points to the remedy of the problem: setting $\zeta = 0$ in eq. 3.37. Therefore the matrix [B] becomes

$$[\,B\,] = \begin{bmatrix} -\frac{1}{l} & 0 & \frac{y}{l} & \frac{1}{y} & 0 & -\frac{y}{l} \\ \\ 0 & -\frac{1}{l} & -\frac{1}{2} & 0 & \frac{1}{l} & -\frac{1}{2} \end{bmatrix} \qquad 3.38$$

As stated earlier, a uniaxial stress-strain relationship is used. Therefore, the stress-displacement relationship may be defined as

$$\{\,\sigma\,\} = [\,E\,]\{\,\varepsilon\,\} = [\,E\,][\,B\,]\{\,d\,\}$$

where 3.39

$$[\,E\,] = \begin{bmatrix} E & 0 \\ 0 & G \end{bmatrix}, \qquad G = \frac{E}{2\,(\,1+\nu\,)}$$

Normal strains $\{\delta\varepsilon\}$ corresponding to a virtual displacement vector $\{\delta d\}$ are given by

$$\{ \delta\varepsilon \} = [B] \{ \delta d \} \tag{3.40}$$

and the internal work done by the stresses may be obtained as

$$\delta W_i = \int_v \{ \sigma \} \{ \delta\varepsilon \} dv \tag{3.41}$$

or by substituting eqs. 3.39 and 3.40 nto eq. 3.41 as

$$\delta W_i = \int_v [E] [B] \{ d \} [B] \{ \delta d \} dv \tag{3.42}$$

Under the action of the external nodal forces $\{f\}$, where

$$\{ f \} = (f_1 \; q_1 \; m_1 \; f_2 \; q_2 \; m_2)^T \tag{3.43}$$

and the applied virtual displacements $\{\delta d\}$, some external work is performed by those nodal forces and may be written as

$$\delta W_e = \{ f \}^T \{ \delta d \} \tag{3.44}$$

By equating 3.41 and 3.44, seeking equilibrium between internal and external works, the nodal forces may be expressed as

$$\{ f \} = \int_v [E] [B] \{ d \} [B] dv$$

or

$$\{ f \} = [\int_v [B]^T [E] [B] dv] \{ d \} \tag{3.45}$$

which define the element stiffness matrix [k] as

$$[k] = \int_v [B]^T [E] [B] dv \tag{3.46}$$

The coefficients of the [k] matrix are obtained by performing the integration in eq. 3.46 as shown for the first coefficient k11

$$k_{II} = \int_v (- \frac{1}{l})^2 E \, dv = \frac{1}{l^2} \int_l EA \, dx = \frac{EA}{l} \tag{3.47}$$

By applying a similar procedure to the coefficients the complete matrix is obtained as

$$[\,k\,] = \begin{bmatrix} \frac{EA}{l} & 0 & -\frac{ES}{l} & -\frac{EA}{l} & 0 & \frac{ES}{l} \\ & \frac{GA}{l} & \frac{GA}{2} & 0 & -\frac{GA}{l} & \frac{GA}{2} \\ & & \frac{EI}{l} + \frac{GA}{4} & \frac{ES}{l} & -\frac{GA}{2} & -\frac{EI}{l} + \frac{GAl}{4} \\ & & & \frac{EA}{l} & 0 & -\frac{ES}{l} \\ \text{symmetric} & & & & \frac{GA}{l} & -\frac{GA}{2} \\ & & & & & \frac{EI}{l} + \frac{GAl}{4} \end{bmatrix} \qquad 3.48$$

where

$$EA = \int E \, dA \;, \qquad ES = \int Ey \, dA \quad \text{and} \quad EI = \int E \, y^2 \, dA$$

In the development of the isoparametric beam element it is not necessary to take the reference x-axis along the neutral axis. Therefore, the integral for ES is not necessarily zero.

3.2.3 Initial Strains

When studying the effects of prestressing and temperature variation in bridge beams, these effects are applied by specifying initial strains to an element. Such procedure is rather simple and may be shown as follows.

Let us assume that an initial strain vector $\{\varepsilon_o\}$ is specified to a beam element as shown in Fig. 3.2. According to eq. 3.39, the final state of stress may be written as

$$\{ \sigma \} = [E] \{ \varepsilon - \varepsilon_0 \} \qquad 3.49$$

where $\{\varepsilon\}$ is the current strain vector of the system exclusive of the effects contained in $\{\varepsilon_o\}$. Equating 3.39 and 3.45 the vector of nodal forces may be written as

$$\{ f \} = \int_V [B]^T \{ \sigma \} \, dv \qquad 3.50$$

and substituting 3.49 into 3.50 as

$$\{ f \} = \int_V [B]^T [E] \{ \varepsilon \} \, dv - \int_V [B]^T [E] \{ \varepsilon_0 \} \, dv \qquad 3.51$$

The first term in eq. 3.51 may be identified with eq. 3.45 whereas the latter term may, accordingly, be written as a vector of nodal forces like

$$\{ f \} = [k] \{ d \} - \{ f_0 \} , \quad \{ f_0 \} = \int_V [B]^T [E] \{ \varepsilon_0 \} \, dv$$

or

$$\{ f \} + \{ f_0 \} = [k] \{ d \} \qquad 3.52$$

The vector of nodal forces $\{f_o\}$ represents the effect of the specified strains $\{\varepsilon_o\}$ on the element. Thus, according to eq. 3.52, it can be added to the current vector of nodal forces $\{f\}$.

3.2.4 Prestressing Effect

As mentioned earlier in this chapter the precast or cast-in-place girders of a bridge structure may be of prestressed concrete, among other methods of construction. Prestressing forces are taken into account by specifying initial prestressing strains in the tendons. The tendons initial strains ε_{po} are defined as the strains due to prestressing forces before releasing of the forces, i.e. the prestressing strain at the zero deflection state of the member. Since the initial prestressing force in a tendon is usually known, the strain that produces that stress level can be obtained from the stress level and the instantaneous stress-strain relationship of the tendon steel as shown in Section 2.3.1 as

$$\varepsilon_{po} = - \frac{N_{po}}{A_p\, E_p} \qquad 3.53$$

where

Npo = Initial prestressing force, including friction loss, if any.

Ap = Cross-sectional area of the tendons.

Ep = Modulus of elasticity of the prestressing steel.

After transfer of the prestressing forces and throughout the life of the member the cable forces vary continually in time and along the length of the cable as well. To introduce this variational effect into the analysis a procedure has been devised so as to introduce the constant presence of the prestressing tendons into the mathematical formulation of the elements that model the member. In such a way any variation in the elements displacement field is automaticaly imposed upon the tendons, and vice-versa. The variable tendon force may be expressed as

$$N_p = E_p\, A_p\, (\, \varepsilon_{pd} - \varepsilon_{po}\,) \qquad 3.54$$

where ε_{pd} is the current strain at the level of the prestressing steel due to effects other than prestressing.

By assuming that:

i) the tendon profiles can be represented by their centroidal lines,

ii) tendons may be approximated as straight within the length of an element,

iii) the tendon force may be taken as constant within each element,

iv) complete bond exists between the tendons and the concrete,

the following relations between displacemets at the element nodal points and displacements at the extremities of the tendon can be drawn, according to Fig. 3.3.

$$u_{pi} = u_i - \theta_i \, y_{pi} \qquad 3.55$$

$$w_{pi} = w_i \qquad , \quad i = 1, 2$$

The axial displacements of the cable, at points 1 and 2, may also be expressed in terms of the nodal displacements by

$$\Delta_i = (u_i - \theta_i \, y_{pi}) \cos\alpha - w_{pi} \sin\alpha \qquad 3.56$$

The relationship between the tendon strains and the nodal displacements is

$$\varepsilon_{pd} = \frac{1}{l_p} (\Delta_2 - \Delta_1) = (B_p) \{ d \} , \qquad l_p = l / \cos\alpha \qquad 3.57$$

where

$$(B_p) = \frac{1}{l_p} \begin{Bmatrix} -\cos\alpha \\ \sin\alpha \\ y_{p1} \cos\alpha \\ \cos\alpha \\ -\sin\alpha \\ -y_{p2} \cos\alpha \end{Bmatrix}^T$$

According to Section 3.2.3, the vector of nodal forces due to

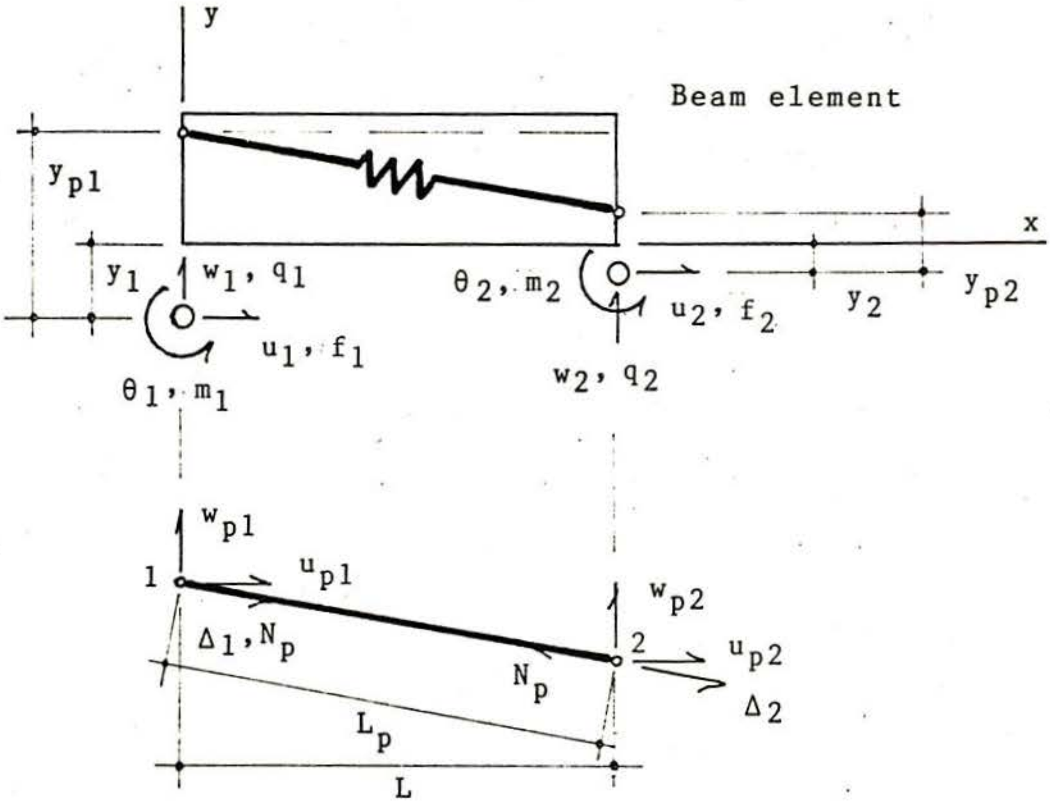


Fig 3.3 - Prestressing cable model.

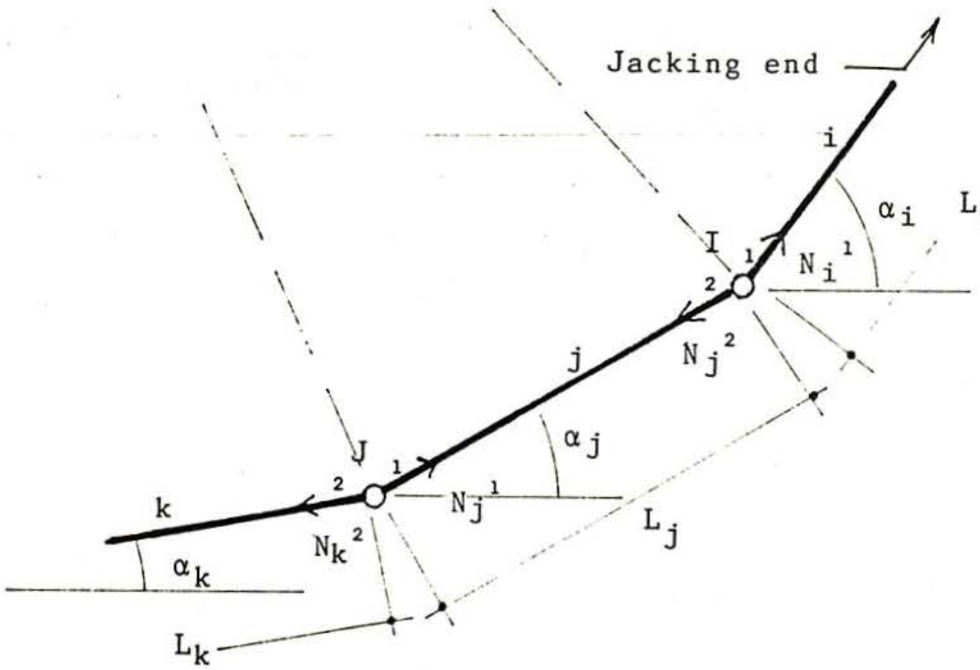


Fig 3.4 - Prestressing force variation due to friction.

$$[k_p] = \frac{E_p A_p}{L} = \begin{bmatrix} \cos^3\alpha & -\sin\alpha\cos^2\alpha & -y_{p1}\cos^3\alpha & -\cos^3\alpha & \sin\alpha\cos^2\alpha & y_{p2}\cos^3\alpha \\ & \sin^2\alpha\cos\alpha & y_{p1}\sin\alpha\cos^2\alpha & \sin\alpha\cos^2\alpha & -\sin^2\alpha\cos\alpha & -y_{p2}\sin\alpha\cos^2\alpha \\ & & y_{p1}^2\cos^3\alpha & y_{p1}\cos^3\alpha & -y_{p1}\sin\alpha\cos^2\alpha & -y_{p1}y_{p2}\cos^3\alpha \\ & & & \cos^3\alpha & -\sin\alpha\cos^2\alpha & -y_{p2}\cos^3\alpha \\ & & & & \sin^2\alpha\cos\alpha & y_{p2}\sin\alpha\cos^2\alpha \\ & & & & & y_{p2}^2\cos^3\alpha \end{bmatrix}$$

prestressing may be expressed as

$$\{ f_p \} = \{ f_{pd} \} + \{ f_{po} \} = [k_p] \{ d \} \tag{3.58}$$

where

$\{f_{pd}\}$ = Nodal forces due to variation of the prestressing force Np caused by deformation of the member.

$\{f_{po}\}$ = Nodal forces due to initial prestressing force Npo and further losses from relaxation.

$$= \int_v (B_p)^T E_p \, \varepsilon_{po} \, dv$$

$$= - l_p (B_p)^T N_{po}$$

$[k_p]$ = Stiffness matrix of the tendon as shown in page 74

$$= \int_v (B_p)^T E_p (B_p) \, dv$$

$$= A_p E_p l_p (B_p)^T (B_p)$$

Initially, the vector $\{f_{po}\}$ is used to perform an analysis of the beam system to evaluate the initial strains $\{\varepsilon_{po}\}$ in the beam element. Subsequently, any changes in the value of Np are automatically accounted for in the analyses of the assembled beam-prestressing tendon system. In pre-tensioned beams all analyses are performed by including the tendon stiffness matrix [kp] into the beam element stiffness matrix [k]. Therefore, losses due to elastic shortening in the member are obtained. On the other hand, in post-tensioned members the above mentioned stiffness matrices are superposed only after the first analysis has been performed, i.e. after the effects of initial prestressing have been obtained.

The post-tensioned tendons, due to the curvature of the profile and also due to out-of-plane deflection or wobble, present a variation of the prestressing force along its length, even before this force is transferred to the concrete member. This loss of the prestressing force, due to friction, is a function of the stress in the tendon, its profile, wobble and the coefficients of friction between the tendons and the surrounding materials.

The PCI Committee on Prestress Losses (23) recommends an expression to estimate the variation of the prestressing force, for a single end force, as follows:

$$N_{p1} = N_{po}\, e^{-(\mu\phi + kx)} \qquad 3.59$$

where

$Np1$ = steel force at a point

Npo = steel force at the jacking end

e = base of the Neperian logarithm

μ = curvature friction coefficient

k = wobble friction coefficient

ϕ = total angular change of prestressing tendon profile, in radians, from jacking end to the point of interest

x = length along the prestressing tendon from jacking end to the point of interest

In the numerical solution, once the continuous cable profile is discretized into straight segments within the length of each element, the application of eq. 3.59 must be adapted for the calculation of the end forces applied at each nodal point. Referring to Fig. 3.4, assume a string of elemental cable segments, i, j and k, for which the jacking end is positioned somewhere before segment i. And further assume that the change in the angular direction between two consecutive nodal points, I and J, can be expressed by the average of the changes of the angular directions at nodes I and J, weighted by the length of the adjacent elements as

$$\phi_j = \phi_{ij} \frac{l_j}{l_i + l_j} + \phi_{jk} \frac{l_j}{l_j + l_k} \qquad 3.60$$

where

$$\phi_{ij} = | \alpha_i - \alpha_j | , \qquad \phi_{jk} = | \alpha_j - \alpha_k | \qquad 3.61$$

The prestressing force at the center of the element Nj can then be obtained as the average of the forces at the nodal points I and J, N_j^1 and N_j^2 respectively as

$$N_j = \frac{1}{2} (N_j^1 + N_j^2) = \frac{1}{2} N_j^2 [1 + e^{-(\mu\phi_j + kl_j)}] \qquad 3.62$$

where N_j^2 has been previously obtained when calculating the force in element i, since equilibrium must be maintained at the nodes and consequently $N_j^2 = N_i^1$.

3.2.5 Temperature Effect

Bridges are usually exposed to the variable climatic conditions. Depending on its geographic location, temperature variation may be quite extensive not only due to seasonal changes but also within a daily cycle. Numerous random factors contribute to temperature distribution on a bridge, namely: the surrounding air temperature, the solar energy striking a surface, convection caused by the wind and various forms of precipitations. As those conditions change continuously temperature distribution varies with position and time.

Hoffman, et al [80], studying temperature effects on a experimental segmental concrete bridge, have shown that the vertical temperature gradient among the cross-sections is highly nonlinear although little variation has been noticed in the longitudinal and transversal directions. This highly unpredictable phenomenon, according to some investigators [80,81,82], is somewhat neglected in today's design codes, though it is frequently the main cause of structural distress if inadequate provisions are considered in design. In jointless long span bridge construction this effect is of paramount importance.

In the present study thermal effects are analyzed considering a given temperature distribution over the composite cross-section, though stationary in time and nonvariable along the length of the member. A nonlinear temperature gradient is approximated by a bilinear variation as shown in Fig. 3.5, with the input values of the temperatures at top, deck-girder interface and bottom, T1, T2 and T3 respectively.

The inclusion of temperature effects in a finite element solution is straight forward and its formulation can be found in most books [76,77]. Temperature variation at any given point ΔT induces a thermal strain ε_T, which may result in a stress-free strain or cause an additional stress, provided that free deformation is prevented. Assuming as the coefficient of thermal expansion of the material, the final strains may be expressed as

$$\varepsilon_T = \alpha \, \Delta T \qquad 3.63$$

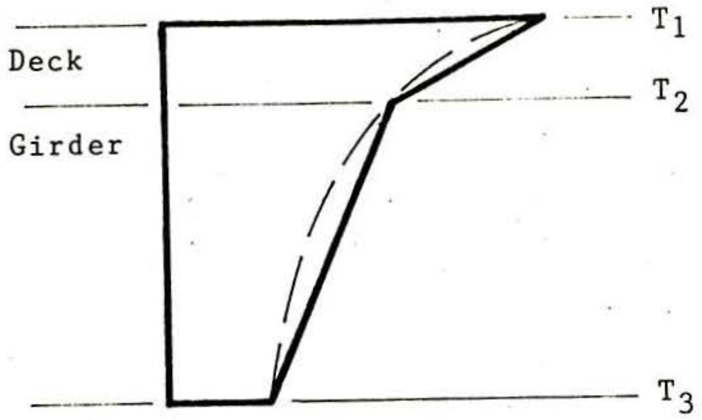


Fig 3.5 - Temperature variation in the cross-section.

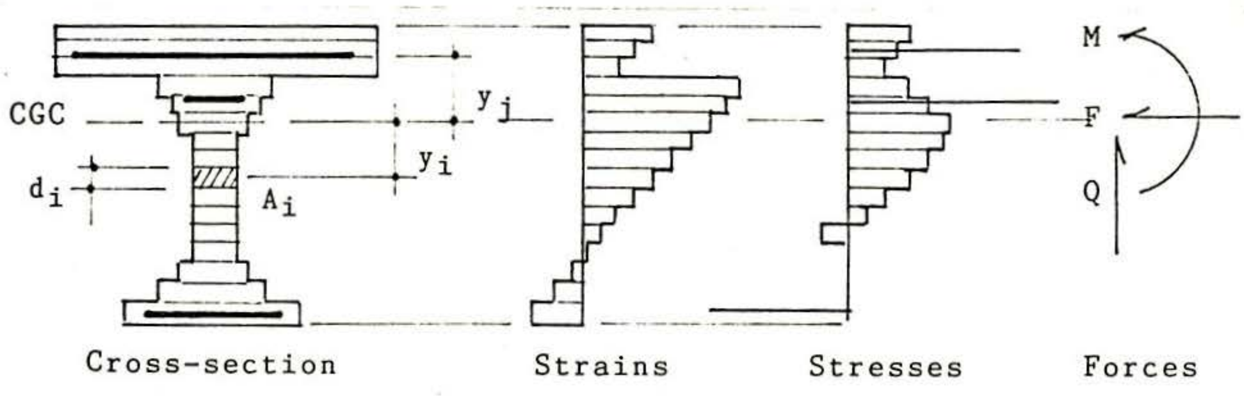


Fig 3.6 - Layered cross-section and stress and strain distributions.

These strains are treated as initial strains as described in Section 3.2.3.

3.2.6 Layered Section

To simplify the discussion, stiffness of the isoparametric beam element has been derived in Section 3.2.2 as if the element consists of one material having constant modulus of elasticity. In reality the beam cross-section consists of two distinct materials, concrete and steel. (Stiffness of the prestressing tendons has been evaluated separately in Section 3.2.4.) Further, the modulus of concrete may vary due to variation in stresses and strains along the y-direction within an element. To account for the variation in material and the modulus along depth, a numerical approach is used to perform integration on the section of an element. The element is divided into several layers, each consisting of one material. Further, depth of each layer is kept sufficiently small such that the stresses within the layer may be assumed constant. Therefore, each layer has a distinct modulus. According to Fig. 3.6, integrals in eq. 3.48 are then replaced by

$$\begin{aligned} \overline{EA} &= \int E\,dA = \Sigma_i\, E_i\, A_i \\ \overline{ES} &= \int Ey\,dA = \Sigma_i\, E_i\, y_i\, A_i \\ \overline{EI} &= \int Ey^2\,dA = \Sigma_i\, E_i\, {y_i}^2\, A_i \end{aligned} \qquad 3.64$$

3.2.7 Coordinate Transformation

Beams rarely have their supports located at the level of their neutral axis, as commonly assumed in basic structural analysis. Supports are generaly provided at the bottom face of the beams and some times even below the bottom flange, as in the case of steel rocker bearings. For accurately modeling the actual supporting conditions of a general beam the adopted elements have their nodes located at a variable position within the vertical planes containing their extreme sections, as shown in Fig. 3.2. The coefficients of the stiffness matrix in eq. 3.46 may be obtained by performing the necessary integrations with respect to the section neutral axis, to the bottom surface as shown in eq. 3.48 or to any other horizontal axis chosen. It is found reasonable to obtain the matrix [k] with respect to the bottom surface of the element, as a general rule. Should the nodes be located at a variable position y from this surface a linear transformation is performed as shown below.

Assuming that $\{d\}$ are the displacements of a node positioned at the bottom surface of the element and $\{\bar{d}\}$ are the displacements of a point positioned at a general location y from this surface, the following relations can be drawn.

$$u = \bar{u} - y\bar{\theta}$$

$$w = \bar{w} \qquad 3.65$$

$$\theta = \bar{\theta}$$

or for the element

$$\begin{Bmatrix} u_1 \\ w_1 \\ \theta_1 \\ u_2 \\ w_2 \\ \theta_2 \end{Bmatrix} = \begin{bmatrix} 1 & 0 & -y_1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & -y_2 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \begin{Bmatrix} \bar{u}_1 \\ \bar{w}_1 \\ \bar{\theta}_1 \\ \bar{u}_2 \\ \bar{w}_2 \\ \bar{\theta}_2 \end{Bmatrix} \qquad 3.66$$

which leads to the definition of the transformation matrix [A] as

$$\{ d \} = [A] \{ \bar{d} \} \qquad 3.67$$

Using the principle of virtual work one can show that

$$\{ \bar{f} \} = [A]^T \{ f \} \qquad 3.68$$

Regardless where the nodes are located the equilibrium equation can still be written as

$$\{ f \} = [k] \{ d \}$$

or

$$\{ f \} = [\bar{k}] \{ \bar{d} \} \qquad 3.69$$

where $[\bar{k}]$ is the transformed element stiffness matrix for the case where the nodes are shifted to a general position away from the bottom surface. By substituting eqs. 3.67 and 3.68 into eq. 3.69, the new transformed element stiffness matrix is obtained as

$$[\bar{k}] = [A]^T [k] [A] \qquad 3.70$$

where [k] is the element stiffness matrix as defined in eq. 3.48 and [A] is the transformation matrix defined in eq. 3.68.

3.2.8 Bearing Supports

Bearing supports are widely used in bridge beams, as explained in Section 2.4. In the present study bearing supports are modeled as uniaxial spring-like elements attached to the respective nodal points as shown in Fig. 3.2. As such, their axial stiffnesses [kb] are calculated with the procedure outlined in Section 2.4 and added to the corresponding degrees-of-freedom of the element stiffness matrix, as shown in the following section.

3.2.9 Element Equilibrium Equation

The elements formulated previously are subjected to nodal forces from the externally applied loading and due to initially prescribed strains. Displacements at the nodal points are related to these nodal forces through the following equilibrium equation.

$$\{ f \} + \{ f_o \} = [k_e] \{ d \} \qquad 3.71$$

where

$\{f\}$ = Vector of externally applied nodal forces.

$\{f_o\}$ = Force vector generated from the initial strains due to prestressing, temperature variation and time-depended effects.

[ke] = Stiffness matrix of the composed element as shown in Fig. 3.2 obtained by superposition of the stiffness matrices of the isoparametric beam element, prestressing tendon and bearing supports, from eqs. 3.48 and 3.58 and Section 3.2.8 respectively.

$[ke] = [k] + [kp] + [kb]$

3.3 Connection Element

A connection element is used to model the single deck connection between two adjacent girders or the deck connection to the end abutment, if any, when no joints are provided in these regions. These connections are very short in length when compared to the dimentions of the cross-section of the beam. They are found to vary in the range of 2 to 6 inches, whether a diaphragm is provided or a gap exists between the two girders [9,39]. The deck has a very small moment of inertia when compared to that of the composite section, especially for the case of concrete girders. It seems reasonable to model the deck connection by a spring like element, which has only axial stiffness and is located at the centroidal line of the deck, away from the centroidal line of the composite section. Although the flexural stiffness of the deck is being disregarded at the connection, the predominant effect of the presence of the deck is accountted for by the rotational restriction provided by the spring, in its offset position from the centroid of the composite section.

The formulation of the connection element is remarkably simpler than the one presented for the beam element and is obtained as follows. Referring to Fig. 3.7, consider that u_1 , w_1 , θ_1 , and u_2 , w_2 , and θ_2, are the displacements of the nodal points 1 and 2, respectively, which are shared by the connection element and the two adjacent beam elements. Consider also that u_1^* and u_2^* are the two horizontal displacements at the centroidal points A and B, at the opposite faces of

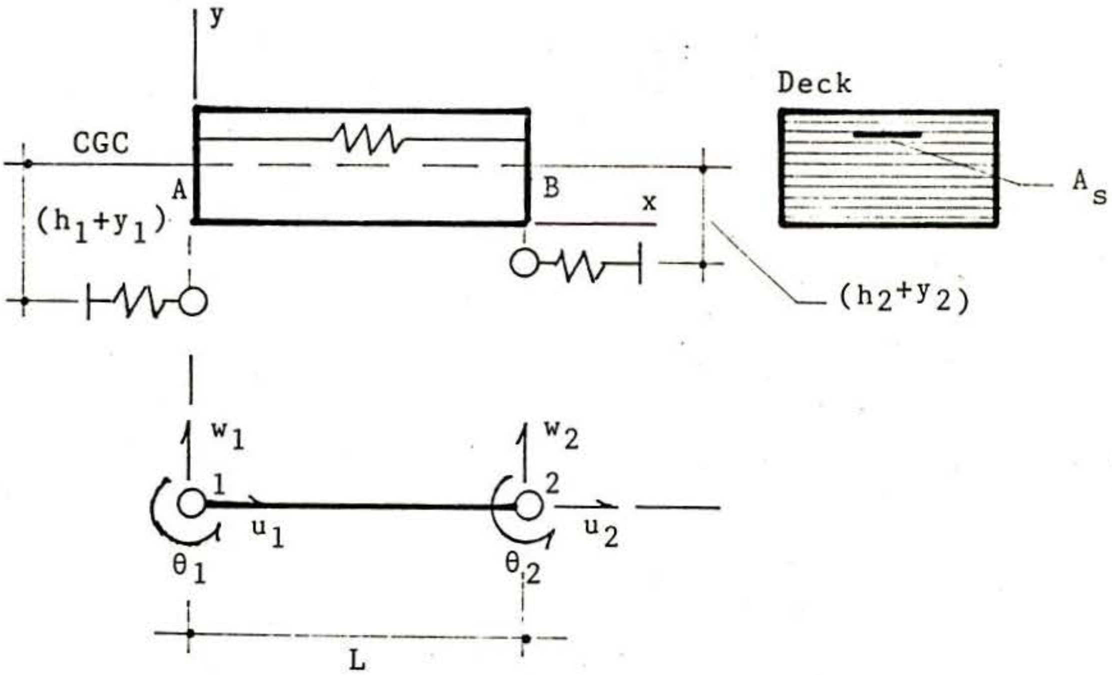


Fig 3.7 - Connection element.

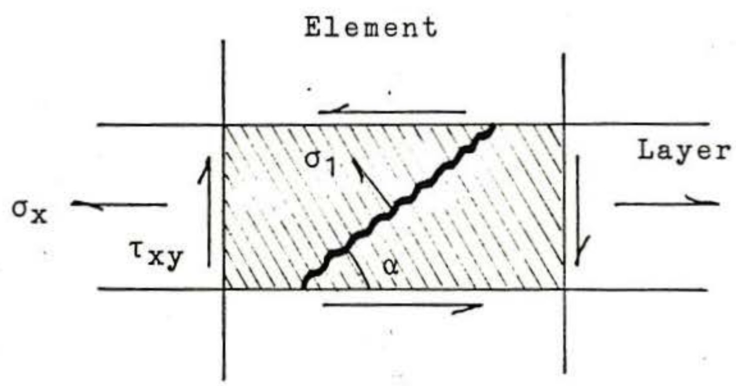


Fig 3.8 - Cracking stress and position.

the connection element. These two sets of displacements can be related to one another by the transformation matrix [T] as

$$\begin{Bmatrix} u_1^* \\ u_2^* \end{Bmatrix} = \begin{bmatrix} 1 & 0 & -(h_1 + y_1) & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & -(h_2 + y_2) \end{bmatrix} \begin{Bmatrix} u_1 \\ w_1 \\ \theta_1 \\ u_2 \\ w_2 \\ \theta_2 \end{Bmatrix} \qquad 3.72$$

or

$$\{ d^* \} = [T] \{ d \}$$

The same transformation matrix can be used to relate the nodal forces $\{f\}$ to the horizontal normal forces $\{f^*\}$ applied at the centroidal points A and B as

$$\{ f \} = [T] \{ f^* \} \qquad 3.73$$

The element equilibrium equation is written as

$$\{ f^* \} = [k_c^*] \{ d^* \} \qquad 3.74$$

where the axial stiffness matrix $[k_c^*]$ is defined by

$$[k_c^*] = \frac{EA}{L} \begin{bmatrix} -1 & 0 \\ 0 & -1 \end{bmatrix} \qquad 3.75$$

By equating 3.72, 3.73 and 3.74 the element equilibium equation relating nodal forces and displacements is given by

$$\{ f \} = [k_c] \{ d \} \qquad 3.76$$

where the matrix [kc] is obtained as

$$[\, k_c \,] = [\, T \,]^T \, [\, k_c^* \,] \, [\, T \,] \tag{3.77}$$

As for the beam element the contribution of the bearing stiffness [kb] at the nodal points is considered by superposing this value to the element stiffness matrix. The final connection element stiffness matrix can be written as

$$[k_c] = \begin{bmatrix} \frac{EA}{L} + k_b & 0 & -\frac{EA}{L}(h_1+y_1) & -\frac{EA}{L} & 0 & \frac{EA}{L}(h_2+y_2) \\ & 0 & 0 & 0 & 0 & 0 \\ & & \frac{EA}{L}(h_1+y_1)^2 & \frac{EA}{L}(h_1+y_1) & 0 & -\frac{EA}{L}(h_1+y_1)\times(h_2+y_2) \\ & & & \frac{EA}{L} + k_b & 0 & -\frac{EA}{L}(h_2+y_2) \\ & & & & 0 & 0 \\ \text{symmetric} & & & & & \frac{EA}{L}(h_2+y_2)^2 \end{bmatrix} \tag{3.78}$$

where

EA = Axial stiffness of the element considering concrete and steel reinforcements.

h1,h2 = Distance from the CGC of the deck section to the bottom surface of the adjacent beam elements, at nodes 1 and 2.

y1,y2 = Distances from the nodal points 1 and 2 to the bottom surface of the adjacent elements.

3.4 Global Problem

Using the finite elements formulated in previous sections a member is modeled as several discrete elements connecting end-to-end at nodal points. It is idealyzed as a straight line passing through these nodal points, each of which having three degrees-of-freedom. The global stiffness matrix of the system is obtained by appropriate assembly of the stiffness matrices of the individual beam elements as shown in eq. 3.70, and connection elements if any, as shown in eq. 3.78. Both elements share a single nodal point and therefore their stiffness matrices are superposed at the common degrees-of-freedom.

The elements are used to represent material and cross-section properties of the member. Loads and restraints in any of the three directions are lumped and applied only at the nodal points. The global equilibrium equation of the system is written as

$$\{ F \} + \{ F_0 \} = [K] [D] \qquad 3.79$$

where

F = Assembled vector of applied loads.

Fo = Force vector generated from initial strains.

[K] = Global stiffness matrix.

D = Vector of nodal displacements.

Under the action of loads, a solution for displacements is performed. Displacements are used for the calculation of strains and, in turn, for obtaining stresses. Element resisting forces, obtained by integrating stresses over the cross-section are eventually transformed back into nodal forces to seek equilibrium of the system. Moments, axial and shear forces are constant within the length of each element and thus their distributions along the length of the member are linearly approximated. The more elements are used for modeling the member, the more accurate is the approximation. Reactions are calculated at the nodal supports and correspond to the resisting forces shared by the elements connected at these nodal points.

Response analysis of a member may include both linear and nonlinear ranges of behavior. Nonlinearity is introduced by the assumed nonlinear properties of the materials as well as due to cracking of the sections as explained in following section. The solution for displacements is performed by an incremental method using the tangent stiffness matrix of the system, either by increments of load or displacement as described in Section 3.8. Time-dependent response analysis is discussed in Section 3.9.

3.5 Loading

A structural member behaves according to the imposed loading and constraints. In the case of composite precast construction these loadings and constraints are very well defined qualitatively, quantitatively, and in time. A numerical analysis, therefore, has to properly model each and all of these conditions in sequence and carrying the current state of the member from one loading stage to the next. In this study, the following seven different loadings are considered

Prestressing

Girders Dead Load

Deck Dead Load

Live Loads

Support Displacements

Temperature

Time-Dependent Effects

Each of the above loadings is applied upon the structure at a predefined time or time interval and subdivided into a specified number of steps whether of load, displacement or time. Prestressing and temperature are applied as equivalent nodal loads as explained in sections 3.2.4 and 3.2.5 respectively. Support displacements will be discussed in Section 3.6 and time-dependent effects in Section 3.9.

Dead loads are linearly distributed along the member and are divided into two categories: girder dead load and deck dead load. The latter includes not only the weight of the deck slab but also of any permanent component like diaphragms, wearing course, cubs and rails, etc. Both dead loads, often applied at different ages of the structure, are modeled as equivalent nodal loads.

Live loads represent any non permanent external action applied to the members due to traffic, wind, earthquakes, etc. Here, however, only vertically and statically applied loads are assumed. Live loads are usually concentrated or distributed within limited regions. In this study the inclusion of any distributed or concentrated live load is accepted. In the analysis, however, they are also modeled by equivalent nodal loads. Within the solution, the response under the action of such loads may be obtained by using the Method of Load Increments as well as by using the Displacement Increment Method, both described in following sections.

In many structural analyses, it is essential to evaluate the strength of a member, i.e. the member response to the ultimate load level. The Displacement Increment Method is suitable for the purpose, according to the reasons mentioned in Sections 3.8.1 and 3.8.2. Appendices A and C show in more detail how to input live and dead loads into the program.

3.6 Support Displacements

Structures are often very sensitive to support displacements. A simple beam would rarely be affected by any small prescribed displacement at the supports. A continuous beam, however, may drastically change its response behavior should its supporting conditions be altered. Vertical displacements at a support of a beam may occur due to a settlement of the supporting structure or an intentional adjustment of one or more of the supporting points.

Two different procedures have been commonly used for the solution of a structural systems under support displacements, and they are briefly outlined as follows. Consider the equilibrium equation of a system, as shown in eq. 3.80, for which some of the degrees-of-freedom have prescribed displacements $\{D_1\}$. Then the remaining desplacements $\{D_2\}$

and the nodal loads associated with the prescribed degrees-of-freedom $\{F_2\}$ are unknowns. The system stiffness matrix is then partitioned accordingly as

$$\begin{bmatrix} [K_{11}] & [K_{12}] \\ [K_{21}] & [K_{22}] \end{bmatrix} \begin{Bmatrix} \{D_1\} \\ \{D_2\} \end{Bmatrix} = \begin{Bmatrix} \{F_1\} \\ \{F_2\} \end{Bmatrix} \qquad 3.80$$

and the unknown displacements and loads can be obtained by solving the following set of equations, respectively.

$$[K_{22}]\{D_2\} = \{F_2\} - [K_{21}]\{D_1\}$$

and 3.81

$$\{F_1\} = [K_{11}]\{D_1\} + [K_{12}]\{D_2\}$$

The above procedure, though mathematically correct, increases enormously the computational work involved in solving the system. Not only the stiffness matrix has to be partitioned, as in eq. 3.80, but also there is one more set of multiplications to be performed, as in eq. 3.81, a process that might be repeated numerous times for a nonlinear system. However, a more economical and as precise procedure may be used to solve the same problem, regarding the level of accuracy of the problem studied and acknowledging the possiblity of numerical weaknesses.

Assume, for convenience of illustration, the same structural system solved by the above procedure, for which one or more degrees-of-freedom have prescribed displacements, Di, Dj, ..., where i, j, ..., represent supporting nodal points. Eq. 3.80 may be written as

$$\begin{bmatrix} \cdots & & & & \\ & K_{ii} & & & \\ & & \cdots & & \\ & & & K_{jj} & \\ & & & & \cdots \end{bmatrix} \begin{Bmatrix} \cdots \\ D_i \\ \cdots \\ D_j \\ \cdots \end{Bmatrix} = \begin{Bmatrix} \cdots \\ F_i \\ \cdots \\ F_j \\ \cdots \end{Bmatrix} \qquad 3.82$$

Where the stiffness matrix [K] does not need to be partitioned and is used as for the solution of any other loading condition. Furthermore, assume that the coefficients of the stiffness matrix, Kii, Kjj, ..., are altered so that they become extremely greater than the other coefficients of the same lines of the matrix, i.e. the remaining coefficients of the equilibrium equations of the nodes in question as

$$K_{ii} = \beta \ K_{ii} , \qquad i = 1, 2 \qquad 3.83$$

where β is a convenient large number as 10^{12} for instance, and in the load vector {F} the corresponding elements, Fii, Fjj, ..., are also altered accordingly so that

$$F_i = \beta \ K_{ii} \ D_i , \qquad i = 1, 2 \qquad 3.84$$

Then, the system of equations 3.82 may be usually solved by any process being employed in the numerical procedure and applied to the remaining loading cases. This procedure, which is more economical than the one described previously has been successfully used by some investigators (83) and is applied in this study.

3.7 Cracking Model

In the analysis of concrete structures the low tensile strength of concrete and the ensuing cracking that results therefrom is of paramount importance. Cracking effect in finite element analysis of reinforced concrete structures was first introduced by Ngo and Scordelis (29) through the use of a predefined discrete crack system. Nilson (30) proposed a model for progressive crack propagation by separating elements at each side of a node and, consequently, having to deal with a continuous change in the topology of the mathematical model.

A second approach was later introduced by Rashid (84) who in studying the behavior of prestressed concrete pressure vessels, proposed the so-called smeared cracking model. In such a model, rather than representing a single crack, many finely spaced cracks perpendicular to the principal strain direction are assumed to occur. This approach has been used by a majority of investigators (33) who acknowledged its main features of permitting an automatic generation of cracks without the redefinition of the finite element topology and the complete generality in possible crack directions.

In the present study, regarding the class of structures analyzed and the type of analysis proposed, the smeared cracking model has been adopted due to its proven efficiency and easy application. Cracking is considered through a strain criteria. It is assumed to happen when the principal strain at a point ε_1 reaches the concrete rupture strain ε_r. Cracks are expected to be oriented perpendicularly to the direction of the principal stress as shown in Fig. 3.8. Considering that normal strains in the vertical direction are disregarded in the formulation

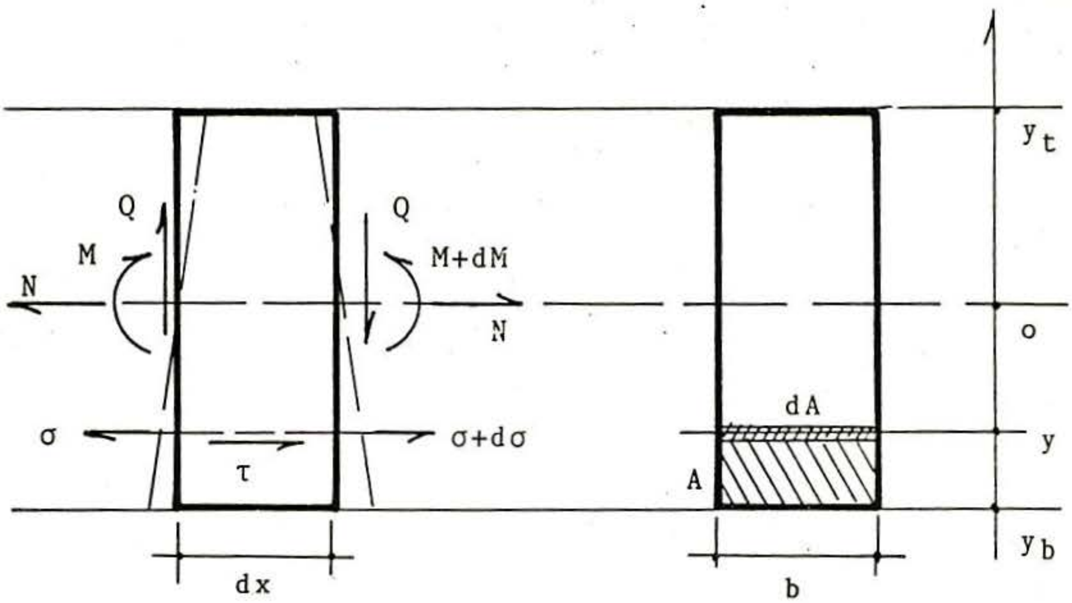


Fig 3.9 - Stress distributions on the cross-section.

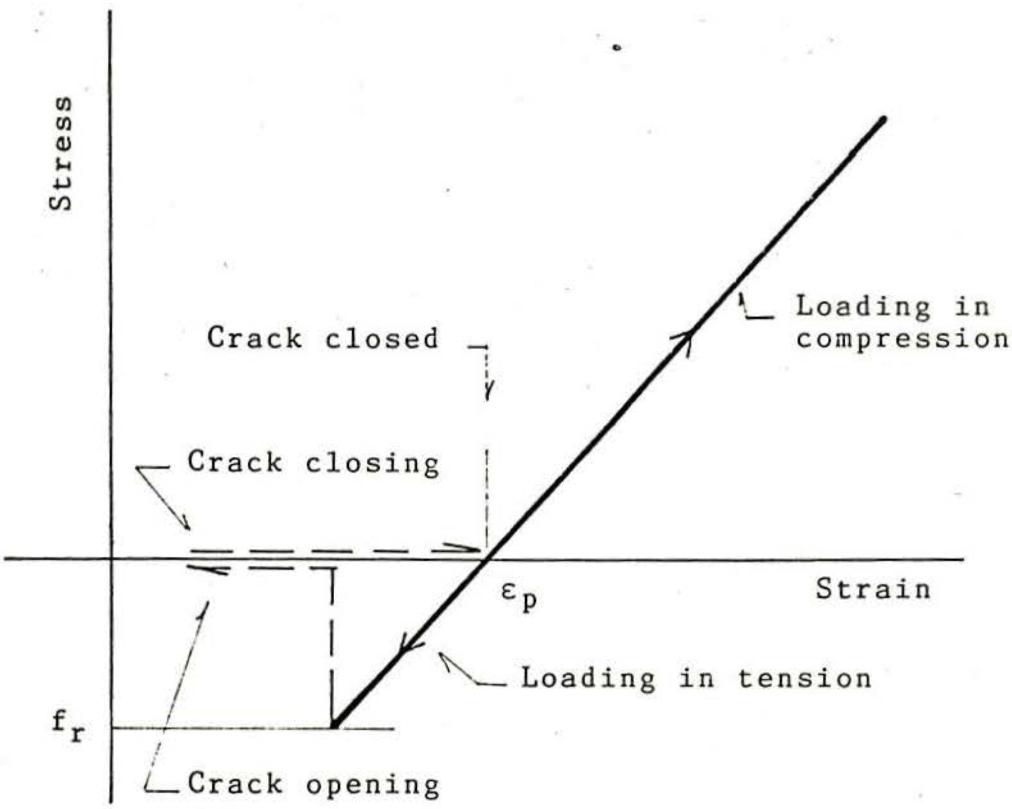


Fig 3.10 - Crack formation and closing.

of the element, as explained in Sections 3.2.1 and 3.2.2, the principal strain at a point may be obtained as

$$\varepsilon_1 = \frac{1}{2} [\varepsilon_x + (\varepsilon_x^{\,2} + \gamma_{xy})^{1/2}] , \quad \varepsilon_x = \frac{\sigma_x}{E} , \quad \gamma_{xy} = \frac{\tau_{xy}}{G} \qquad 3.85$$

and its orientation α by

$$\alpha = \frac{1}{2} \tan^{-1} (\frac{\gamma_{xy}}{\varepsilon_x}) \qquad 3.86$$

where ε_x and γ_{xy} are the normal strain in the axial direction and the shear strain, respectively. From eq. 3.37 and 3.38 it is observed that the normal strain ε_x varies linearly through the depth of the element whereas the shear strain γ_{xy} is constant. The assumption of constant γ_{xy} in the element cross-section is reasonable for modeling the global behavior of the member under a bending mode of deformation. However, shear strains do vary along the depth of the beam, according to the distributions of shear stresses and material properties.

The local distribution of shear stresses may be obtained by equating the equilibrium of an infinitesimal beam element as shown in Fig. 3.9. At a general position y from the section neutral axis the normal strain developed under the applied forces may be written as

$$\varepsilon_x = \frac{N}{EA} + \frac{M}{EI} y = \varepsilon_{xo} + \chi y = (1 \quad y) \begin{Bmatrix} \varepsilon_{xo} \\ \chi \end{Bmatrix} \qquad 3.87$$

and the corresponding normal stress as

$$\begin{aligned} \sigma_x &= E \, \varepsilon_{xo} + E \, \chi \, y \\ &= E \, (1 \quad y) \begin{Bmatrix} \varepsilon_{xo} \\ \chi \end{Bmatrix} \end{aligned} \qquad 3.88$$

The axial force N and bending moment M may be obtained by integrating the above stresses as

$$N = \int_{y_b}^{y_t} \sigma_x \, dA = \varepsilon_{xo} \, \overline{EA} + \chi \, \overline{ES}$$

$$M = - \int_{y_b}^{y_t} \sigma_x \, y \, dA = - \varepsilon_{xo} \, \overline{ES} - \chi \, \overline{EI} \qquad 3.89$$

where

$$\overline{EA} = \int_{y_b}^{y_t} E \, dA \; , \quad \overline{ES} = \int_{y_b}^{y_t} E \, y \, dA \quad \text{and} \quad \overline{EI} = \int_{y_b}^{y_t} E \, y^2 \, dA \qquad 3.90$$

Equation 3.89 may also be written in matrix form as

$$\begin{Bmatrix} N \\ M \end{Bmatrix} = \begin{bmatrix} \overline{EA} & \overline{ES} \\ - \overline{ES} & - \overline{EI} \end{bmatrix} \begin{Bmatrix} \varepsilon_{xo} \\ \chi \end{Bmatrix} \qquad 3.91$$

or

$$\begin{Bmatrix} \varepsilon_{xo} \\ \chi \end{Bmatrix} = \frac{1}{\overline{ES}^2 - \overline{EA} \, \overline{EI}} \begin{bmatrix} - \overline{EI} & - \overline{ES} \\ \overline{ES} & \overline{EA} \end{bmatrix} \begin{Bmatrix} N \\ M \end{Bmatrix} \qquad 3.92$$

Substituting eq. 3.92 into eq. 3.88 and proceeding with a matrix multiplication, the normal stress may be written as

$$\sigma_x = \frac{E}{\overline{ES}^2 - \overline{EA} \, \overline{EI}} \left[\left(-\overline{EI} + \overline{ES} \, y \right) N + \left(-\overline{ES} + \overline{EA} \, y \right) M \right] \qquad 3.93$$

According to Fig. 3.9 the equilibrium between normal and tangential stresses may be equated as

$$\tau_{xy} \, b \, dx = - \int_{y_b}^{y} d\sigma_x \, dA \qquad 3.94$$

and therefore the shear stress is given by

$$\tau_{xy} = -\frac{1}{b}\int_{y_b}^{y} \frac{d\sigma_x}{dx}\, dA \qquad 3.95$$

By assuming the reference axis y for the integrals in eq. 3.90 as the section centroidal axis as shown in Fig. 3.9, ES = 0. Taking the derivative of eq. 3.93 and substituting into eq. 3.95 the shear strain is obtained as

$$\tau_{xy} = \frac{1}{b}\int_{y_b}^{y} \left(\frac{E}{\overline{EA}\ \overline{EI}} \right) \left(-\overline{EI}\frac{dN}{dx} + \overline{EA}\, y \frac{dM}{dx} \right) dA \qquad 3.96$$

Normal force N is constant through the element and the variation of the bending moment M with x is represented by the total shear force Q. The integration in eq. 3.96 leads to eq. 3.97 and using the expression in eq. 3.90 becomes

$$\tau_{xy} = \frac{Q}{b} \left(\frac{\overline{ES\ y}}{\overline{EI}} \right) \qquad 3.97$$

Should material properties E be constant through the depth, eq. 3.97 would become the common expression for the distribution of shear stresses

$$\tau_{xy} = \frac{QS}{bI} \qquad 3.98$$

where S stands for the first moment of area of the area A in Fig. 3.9 and I stands for the moment of inertia of the section. Both S and I are calculated with respect to the centroidal axis of the section. The above expression generally leads to a parabolic shear stress distribution. In the present study, material properties do vary throughout the sections as a consequence of the nonlinear stress-strain relationships assumed for the materials. Therefore, the shear stress and consequent shear strain distributions must be obtained from eq. 3.97, where the quantities $\overline{ES}_y$ and $\overline{EI}$ carry the effects of material nonlinearity. For computing the principal strain at a general point or layer, as in eq. 3.85, the shear strain γ_{xy} is then obtained as

$$\gamma_{xy} = \frac{\tau_{xy}}{G} = \frac{Q}{bG} \left(\frac{\overline{ES}\ y}{\overline{EI}} \right) \qquad 3.99$$

where G is the shear modulus of the material at the point of interest, taken as $G = E/2(1+\nu)$.

The above procedure accounts for the variation of the material properties not only with the different materials that may comprise the beam but also within the same material. Once a crack is formed one or more layers of an element are considered cracked, their axial stiffnesses are disregarded by setting the modulus of elasticity to zero. The analysis then proceeds and crack propagation is obtained by applying the same procedure to the consecutive layers.

In a structural member, however, even when monotonic loading is applied it is possible for some stress redistribution to take place causing some regions of the member to unload. This phenomenon may be due to intrinsic nonlinear stress-strain characteristics of the materials, or the cracking process, or the time-dependent effects that exist, and may cause some cracks to close. If that should happen a strain quantity ε_p is observed, see Fig. 3.10, and crack closing is obtained whenever this value is surpassed when concrete is able to pick up compressive stress normal to the closed crack.

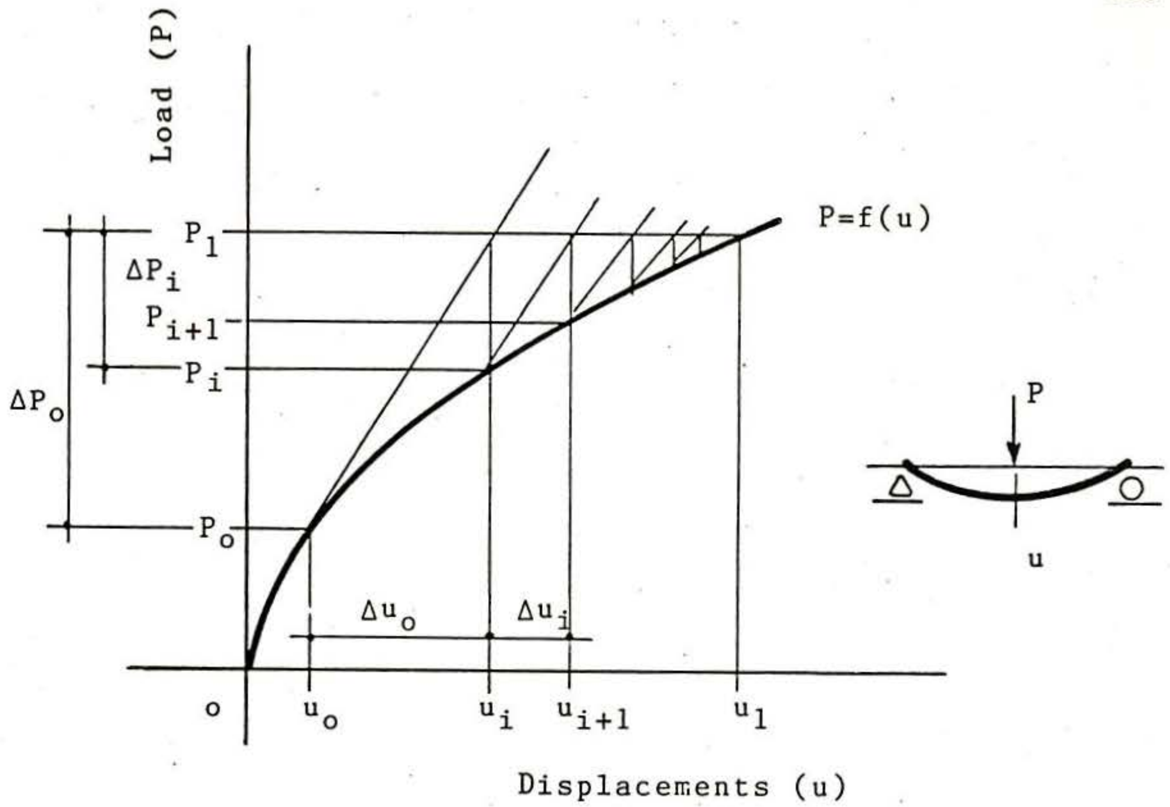


Fig 3.11 - Load Increment Method.

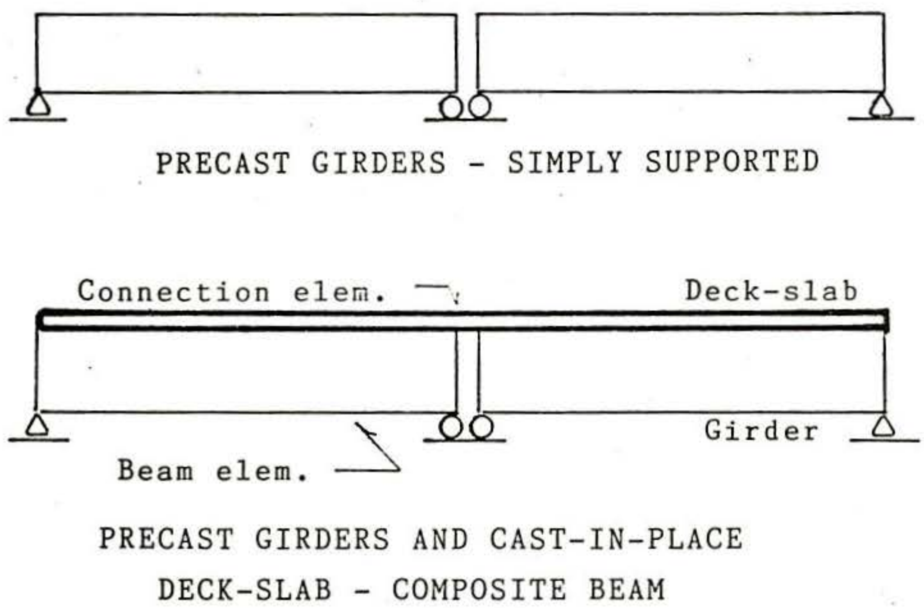


Fig 3.12 - Sequence of construction of a two-span composite beam.

3.8 Nonlinear Analysis

3.8.1 The Load Increment Method

The Load Increment Method for nonlinear analysis uses an iterative procedure in which the loads applied to the system are successively corrected until an equilibrium position is obtained. It is a variation of the direct stiffness technique where the incremental stiffness matrix based on the current position of the system is used, instead of a constant stiffness matrix, and equivalent to the modified Newton-Raphson Method.

For illustration of the method, consider a single degree-of-freedom system as shown in Fig. 3.11. Assume that the load-deformation relationship of the system can be represented by the function

$$P = f(u) \qquad 3.100$$

and further assume that the current state of the system is at the load level p and at the deformation u_o. It is required to determine the deformation at the new load level p_1, u_1. A new step starts with a predefined load increment Δp_0. By assuming that the load deformation relatioship is linear at that deformation level and, therefore, using the tangent stiffness at that level as the stiffness of the system a deformation increment is calculated as Δu_0. The current deformed state is then obtained as

$$u_i = u_o + \Delta u_o \qquad 3.101$$

and the resisting internal forces at this deformation level as

$$P_i = f(u_i) \qquad 3.102$$

For a nonlinear system p_i will rarely be equal to p_1 and the difference

$$\Delta P_i = P_1 - P_i \qquad 3.103$$

is the equilibrium error or residual load vector. The residual vector is then compared with the specified tolerance limit. If this limit is exceeded the residual load vector is used as the additional load applied to the system, at the trial deformation level of u_i. This process is repeated until the equilibrium error is within the specified limits. The solution is then assumed to be converged for the load level p_1. The same process is followed for the next load step, if any, when the tangent stiffness matrix is updated. The solution will then converge when an equilibrium state of the system, under the applied load, is obtained.

Under some circunstances such as the case where the new load level exceeds the maximum capacity of the system, or the new load is less than the capacity but with some unusual shape of the load-deformation relationship, the solution may diverge. An unusual shape of the load-deformation relationship in the case of stuctural members may be the nearly horizontal plateau observed at the level of their maximum capacity.

3.8.2 The Displacement Increment Method

The nonlinear response of a structural member, within some limiting points, can be predicted by using various numerical techniques like the Newton-Raphson Method and its modified version, the Incremental Stiffness Method, the first and second order Self Correcting Method, etc. When these methods are used in terms of the incremental load vectors convergence may become difficult to achieve, whenever the sought track has some particular shape as mentioned in the previous section. In the analysis of concrete structures the load-deflection curves may frequently present sudden drops due to instantaneous reduction in stiffness, as a consequence of cracks. They are also frequently characterized by possessing a flat plateau which may follow large increments in displacements, an important phenomenon for the measure of ductility. The displacement increment technique, however, has proven very effective in capturing the complete load-deformation curve including these particular drops and plateau. A few different versions of the method are found in the literature (85,86,87) and some investigators have reported using it with satisfactory results (88).

For illustration purpose, assume the equilibrium equation of a structural system relating displacements and applied loads as

$$[\,K\,]\,\{\,D\,\} = \{\,F\,\} \qquad 3.104$$

If an incremental procedure is adopted, eq. 3.104 may be written as

$$[\,K\,]\,\{\,\Delta D\,\} = \Delta\alpha\,\{\,F\,\} \qquad 3.105$$

where [K] is in general a symmetric banded matrix of order n, here taken as the tangent matrix evaluated at the beginning of a new step, $\{\Delta D\}$ is the vector of n unknown displacements, $\{F\}$ the known load vector with n components and $\Delta\alpha$ an unknown factor applied to the load vector.

For applying the Displacement Increment Method to the system in question a single degree-of-freedom is conveniently chosen. A specified displacement ΔD_2 is incrementally applied to the nodal point until the system reaches equilibrium at a desired load level. The displacement vector in eq. 3.105 may then be partitioned into two components, where $\{\Delta D_1\}$ is the unknown incremental displacement vector for the remaining degrees-of-freedom of the system, as in eq. 3.106. The stiffness matrix of the system and the applied load vector from eq. 3.105 may then be partitioned accordingly

$$\begin{bmatrix} [K_{11}] & \{K_{12}\} \\ (K_{21}) & K_{22} \end{bmatrix} \begin{Bmatrix} \{\Delta D_1\} \\ \Delta D_2 \end{Bmatrix} = \Delta\alpha \begin{Bmatrix} \{F_1\} \\ F_2 \end{Bmatrix} \qquad 3.106$$

Eq. 3.106 can also be written as

$$[K_{11}]\{\Delta D_1\} = \Delta\alpha\{F_1\} - \{K_{12}\}\Delta D_2 \qquad 3.107$$

$$(K_{21})\{\Delta D_1\} = \Delta\alpha \; F_2 \; - \; K_{22} \; \Delta D_2 \qquad 3.108$$

A direct method of solving eqs. 3.107 and 3.108 would lead to the use of a non-symmetric matrix, which is not very effective. Nevertheless, by further partitioning the unknown displacement vector as

$$\{\Delta D_1\} = \Delta\alpha\{\Delta D_1\}^0 + \{\Delta D_1\}^1 \qquad 3.109$$

eq. 3.107 can be solved in two simple steps as

$$[K_{11}]\{\Delta D_1\}^0 = \{F_1\} \qquad 3.110$$

and

$$[K_{11}]\{\Delta D_1\}^1 = -\{K_{12}\}\Delta D_2 \qquad 3.111$$

where the matrix $[K_{11}]$, already rearranged for the solution procedure in eq. 3.110 is also used in the subsequent equation, saving some computational effort in repeating the process.

The unknown factor $\Delta\alpha$ can then be obtained by equating 3.109, 3.110 and 3.111 as

$$\Delta\alpha = \frac{(K_{21}) \{ \Delta D_1 \}^1 - K_{22} \Delta D_2}{F_2 - (K_{21}) \{ \Delta D_1 \}^0} \qquad 3.112$$

At this point, equilibrium of the system should be checked as observed for the Load Increment Method. The resisting load vector can be obtained from the current deformed state of the system and, if equilibrium is not achieved, further corrections in the displacement vector should be made. The process followed to this point is the first iteration of a step. For the second and subsequent iterations $\{\Delta D_2\} = 0$ and in its place there is a residual load vector $\{\Delta F_1\}$ and eq. 3.107 and 3.108 may be written as

$$[K_{11}] \{ \Delta D_1 \} = \Delta\alpha \{ F_1 \} + \{ \Delta F_1 \} \qquad 3.113$$

and

$$(K_{21}) \{ \Delta D_1 \} = \Delta\alpha \quad F_2 \quad + \Delta F_2 \qquad 3.114$$

The solution of the above equations, similar to that for eqs. 3.110 and 3.111, can be expressed as

$$[K_{11}] \{ \Delta D_1 \}^0 = \{ F_1 \} \qquad 3.115$$

and

$$[K_{11}] \{ \Delta D_1 \}^1 = \{ \Delta F_1 \} \qquad 3.116$$

where once more the same matrix $[K_{11}]$ is used. $[K_{11}]$ needs to be updated only at the beginning of a new incremental step, if any. Eq. 3.112 is now replaced by

$$\Delta\alpha = \frac{(K_{21})\{\Delta D_1\}^1 - \Delta F_2}{F_2 - (K_{21})\{\Delta D_1\}^0} \qquad 3.117$$

For each iteration the current load vector is obtained as $(\Sigma\Delta\alpha)$ $\{F\}$, where the $\Delta\alpha$'s are to be added for all the previous iterations and steps. Until the residual load vector is sufficiently small when convergence is obtained, the iterations are to be continued.

3.9 Time-Dependent Response Analysis

Section 3.8 describes the procedures utilized for obtaining the instantaneous response of a general composite bridge beam. Concrete members, however, when loaded at different ages may respond quite differently due to the highly nonlinear time-dependent properties of the materials involved, such as creep, shrinkage and aging of concrete, and relaxation of prestressing steel.

Creep is defined as the time-dependent deformations of concrete which is the function of stress levels and the time at which the stesses are applied. Shrinkage represents the time-dependent deformation of concrete that is independent of stress levels and a function of time only. Relaxation is defined as the time-dependent stress decrements of steel under constant strain. The aging of concrete is reflected in the change of the stress-strain curve of the material with time. The stress-strain curve intrinsic shape is assumed to be the same but stresses at a same strain level will be a function of time, as outlined in Section 2.1.3.4.

Time-dependent response analysis may be obtained by subdividing the interval of time under consideration into several small time increments, within which the previously described instantaneous solution is used. In each time increment, or step, it is assumed that material properties and the response of each fiber of the beam follow the functions of time and stress level history up to the start of the time increment. The equilibrium position of the member can be found and is used as the basis for the analysis of the response in the next time step. Starting from the beginning of the time interval the whole range of the time-dependent response can be captured.

Time at which loads are applied is also considered. Loads may be applied any time after the erection time of the beam and they will be accumulated. Some portions of the cross-section of the member may be added later, i.e. the composite beam action is taken into account as described in the following section. External support restraints are generaly independent of time and applied at the beginning of the solution. However, as seen in Chapter 5, some changes in the supporting conditions can be accommodated within the solution.

As previously mentioned, in determining the instantaneous response of a beam, the beam is subdivided into several elements connected end-to-end at nodal points. Each of the elements is further subdivided vertically into layers. A layer is able to carry strains, observed at their centroids, assumed constant throughout their length and cross-section. Loads and restraints are discretized and applied only at the nodal points.

For the time-dependent response analysis it is assumed that the strain in each layer consists of time-dependent strain parts in addition to instantaneous strain parts. Time dependent strains of concrete consist of shrinkage strains and creep strains, and those of prestressing steel are relaxation strains. Shrinkage strains are the function of time alone thus they can be found immediately at any given time increment, assuming the shrinkage function described in Section 3.1.3.3. Creep strains under constant stress may be represented by creep functions. For creep under variable stress, as in a beam, two methods of predicting creep strains under variable stresses may be used. The methods, outlined in Section 2.1.3.2, are the Rate of Creep Method and the Superposition Method. The Rate of Creep Method uses the strain at the beginning of the time increment as the basis for finding the creep increment strain. For the Superposition Method the stress history up to the current time step is used in the calculation. Relaxation strains are treated the same way as the creep strains. But, instead of determining the creep strains, relaxation stresses are calculated from the stress history and only a method similar to the rate of creep method is used. A method similar to the superposition method is invalid since relaxation is not a linear function of stress level.

The so obtained time-dependent strains at any incremental time step are then related to stresses and eventually transformed into nodal forces. The load vector is subsequently applied to the model and an age-corrected instantaneous solution is performed, seeking the current equilibrium position of the member as in the procedure detailed in Section 3.8.1. This process is repeatedly applied for each increment of time and the time-dependent response of the member is obtained.

3.10 Composite Beam Action

Bridge beams are usually constructed as composite beams (9,10,18,39,89,90) where the girders are of precast concrete or steel and the deck slab is cast-in-place on top of the girders at some later date as shown in Fig. 3.12. At the time of casting the deck slab the beams may be shored, i.e. the precast girders do not carry slab loads at the time of casting, or unshored, that is the precast girders carry slab and formwork loads at the time of casting of the slab. After the slab has gained sufficient strength, forming the composite beam, both act together under the additional loads.

For assuring perfect bond between the girders and the deck slab shear connectors are often provided at that interface (10,91). Experimental data show that adequate composite action is obtained when those connections are properly designed (11,92).

In this analysis the following technique is used for modeling the composite behavior at some specified age of the member. As described before, the stiffnesses of the elements are obtained by integrating the individual stiffnesses of the various layers that compose each element. When any new loading is applied, a companion variable ICOMP is assigned a value 0 or 1, indicating that the stiffness integration should be performed within the girder section or extended to the deck portion, respectively. In the early phases of the construction, before the deck is cast, the beam elements represent the behavior of the girders alone. Under the action of deck dead load the variable ICOMP may have its value set to 1 or 0 representing shored or unshored construction, respectively. After the deck has attained enough strength and additional loading is applied, ICOMP remains equal to 1. Composite action is then obtained and the connection elements, if any, link the various spans.

3.11 Program Flow Diagram

With the procedures described in previous sections a method of analysis is developed for both instantaneous and time-dependent responses of a general composite bridge beam. The method can be sumarized by the flow diagram in Fig. 3.13 using the subroutines shown in Fig. 3.14. The steps include reading and printi:g of the input data. A series of time increments is specified and it is assumed that loads and parts of the cross-section are added at different times but only at the beginning of a given time interval. For each time increment an equilibrium position of the member is estimated for the changes in time-dependent strains in each fiber. Additional loads are discretized as nodal point loads and a new equilibrium position of the beam is estimated under the new loading condition. Steps may be omitted if they are not applicable to the time increment being considered and solution output may be printed if needed. The process is repeated for all loading cases and time increments over the interval of interest.

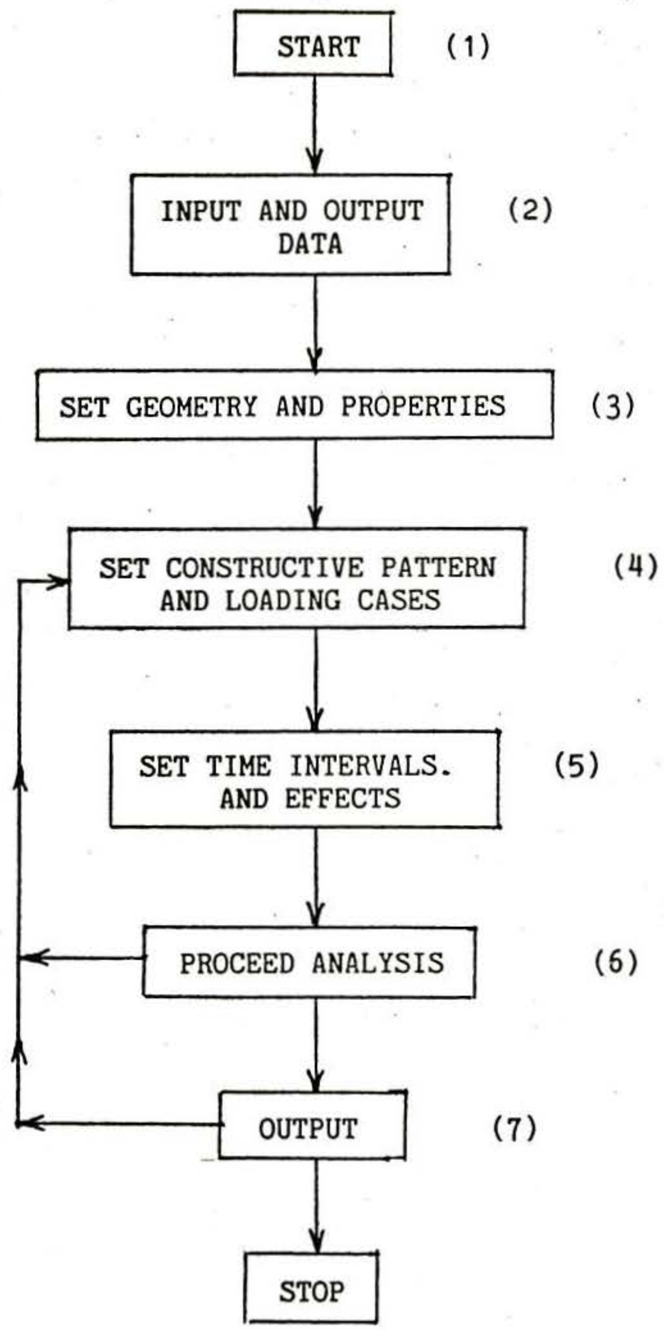


Fig. 3.13 Program's Flow Diagram

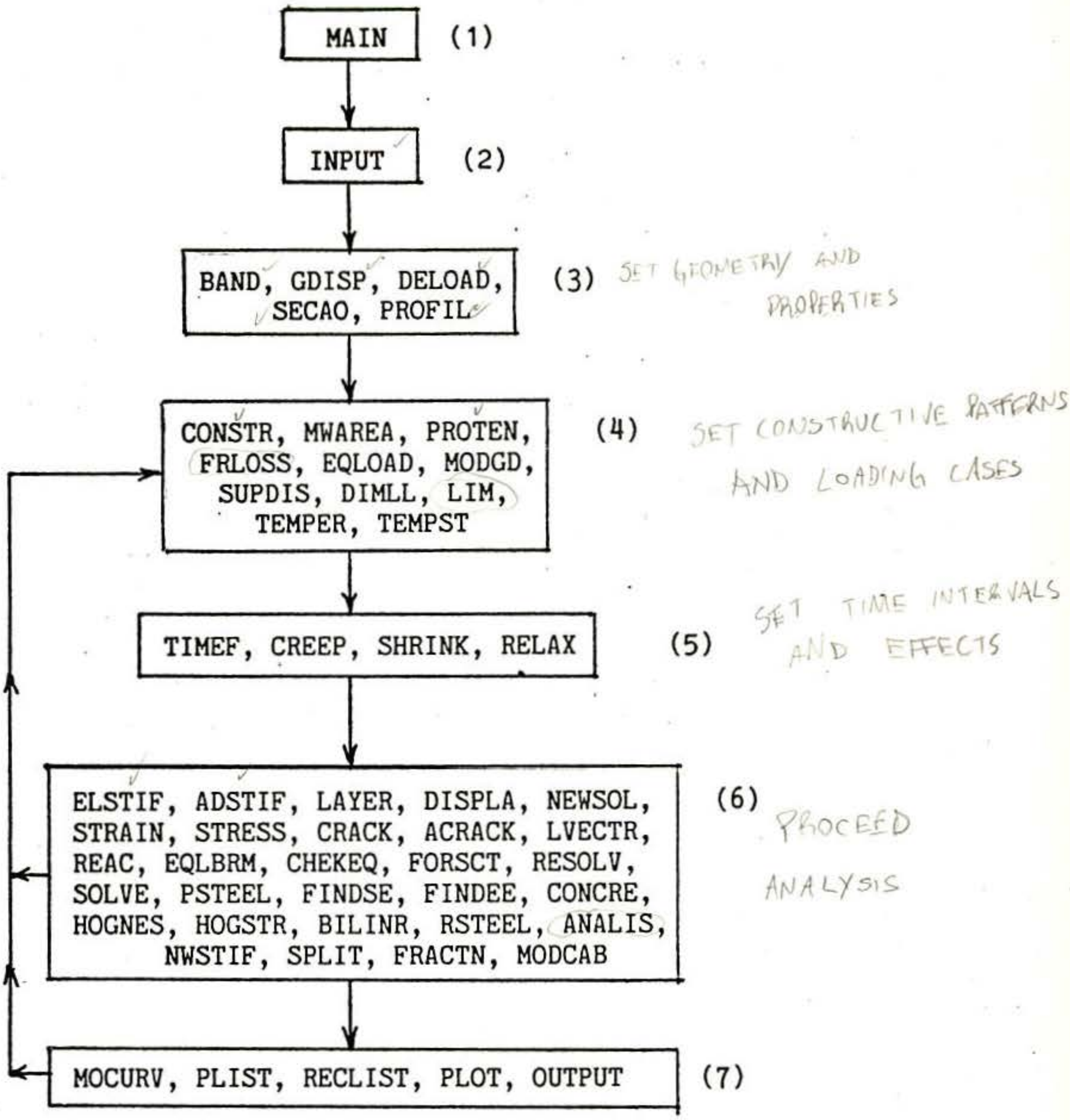


Fig. 3.14 Subroutines for phases in Fig. 3.13

4. VALIDATION OF THE ANALYTICAL MODEL

4.1 Introduction

The proposed program is intended for the analysis of instantaneous and time-dependent responses of non-composite or composite beams, built in steel, reinforced or prestressed concrete, and simple or continuous over two or more spans. Even though its main purpose is aimed at the analysis of beams with continuous deck slabs, as detailed in Chapters 1, 3 and 5, it is also applicable to the analyses of simple and fully-continuous beams. The purpose of this chapter is to validate the analytical model by studying a group of beam members for which analytical and experimental results are available in the literature.

In the following sections, eighteen different beams are analyzed and presented as ten separated problems. Problems 1 to 5, cover the instantaneous response and strength of non-composite and composite beams, in steel, reinforced and prestressed concrete. The remaining five problems cover the time-dependent response of similar beams. Material properties, i.e. stress-strain-time relationships, are based on the assumed models described in Chapter 2. Where actual material properties are known, characteristic constants for the models are adjusted to fit the actual data for each particular case.

4.2 Instantaneous Response and Strength of Non-Composite Beams

4.2.1 Steel I-Beam

A simply supported W18x50 steel I-beam, under a uniformly distributed load over a span of 15 ft, is analyzed for its response up to the ultimate strength [93]. One half of the beam is modeled by 9 beam elements, subdivided vertically into 30 horizontal layers. The load-deflection curve obtained by the use of the Displacement Increment Method with a specified displacement increment of 0.04 in. at the mid section is shown in Fig. 4.1 along with the assumed material properties. The curve compared very closely with analytical results obtained by the elastic theory and the plastic moment presented in Ref. (93).

The analytically obtained plastic moment is 5050 in-lb, whereas the numerically obtained is 5056 in-lb, for an ultimate deflection of 2.9 in, when a plastic hinge is formed at the mid-span.

4.2.2 Reinforced Concrete Rectangular Beam.

In a joint program carried out by the Intituto de Materiales y Modelos Estructurales (IMME) at the Universidad Central de Venezuela, Caracas, Venezuela and the Laboratory for Stuctural Models at MIT, a total of 132 beams at five geometric scales and two reinforcement ratios were tested. Included in the test program were four sets of reinforced concrete beams, having two scale factors with maximum aggregate size of 1 in. and 3/8 in., and eighteen sets of reinforced mortar beams, with five scale factors and maximum size of aggregate of 0.033 in., regardless of scale. From the test results presented by Litle and Paparont [94], and the numerical results by Lazaro and Richards [31], a set of six similar beams, M7.1 to M12.1, with the scale factor of one and reinforcement ratio of 1 % is selected for comparison with the predictions by the author's computer model.

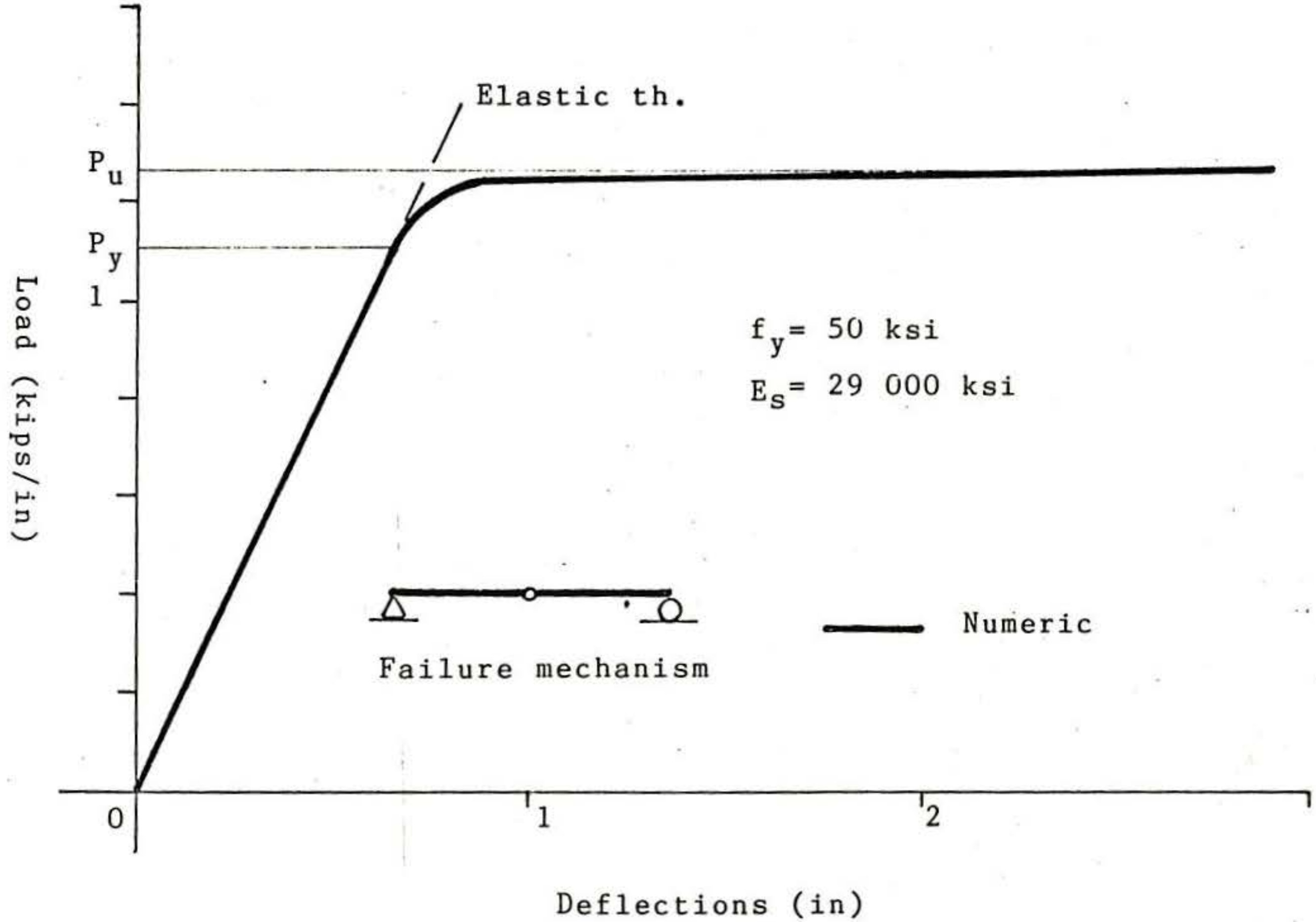


Fig 4.1 - Load-deflection curve for beam Example 4.2.1.

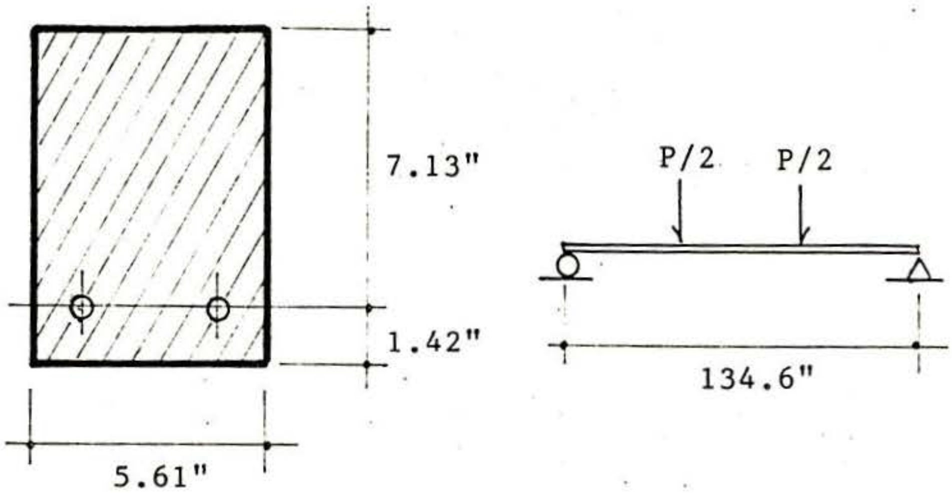
The beams were simply supported and loaded in their third points, and with the cross-section and material properties shown in Fig. 4.2. In the numerical analysis, which led to the load-deflection curves presented in Fig. 4.3, one half of the beam is modeled by 14 elements, subdivided into 30 layers, and the Displacement Increment Method is used, assuming both the Hognestad's and the bi-linear stress-strain relationships for concrete.

A comparison of the results obtained experimentally, analytically and numerically, is also presented in Fig. 4.2. In the post-cracking range the observed results indicate that the beam is stiffer than the numerically predicted behavior due to the absence of the tension stiffening effect in the analytical model. The ultimate mid-span deflection based on bi-linear stress-strain relationship is 33% more than that based on Hognestad stress-strain curve. No observed ultimate deflection is presented in the published results [94].

4.2.3 Prestressed Concrete I-Beam

Keyder [95], reported the testing of two simply supported non-composite pre-tensioned prestressed concrete beams, one of which was also numerically analyzed by Chang [36]. The beam was 14 ft long and loaded symmetrically at the two points 4 ft 6 in from each support. It contained only five prestressed strands as reinforcement and the total initial pre-tensioning force was 70 Kips. (14 Kips./strand).

The cross-section of the beam and the material properties are shown in Fig. 4.4. In modeling the beam, one half of the span is analyzed by



Section and material properties

$A_s = 0.394\ in^2$ $\rho = 0.98\%$

$f'_c = 5070$ psi $f_y = 49$ ksi

Assumed concrete properties

$E_{ci} = 57000 \sqrt{f'_c} = 4\ 060\ 000$ psi

$f_t = 7.5 \sqrt{f'_c} = 534$ psi

Observed and proposed results

	P_{cr}	P_y	P_u	M_u
Observed	---	---	6050	132000
ACI'S	1808	5510	5803	130000
Num.biln.	1740	5550	5820	131000
Num.Hogn.	1716	5490	5730	129000
	(lb)	(lb)	(lb)	(lb/in)

Fig 4.2 - Properties and results for beam Example 4.2.2.

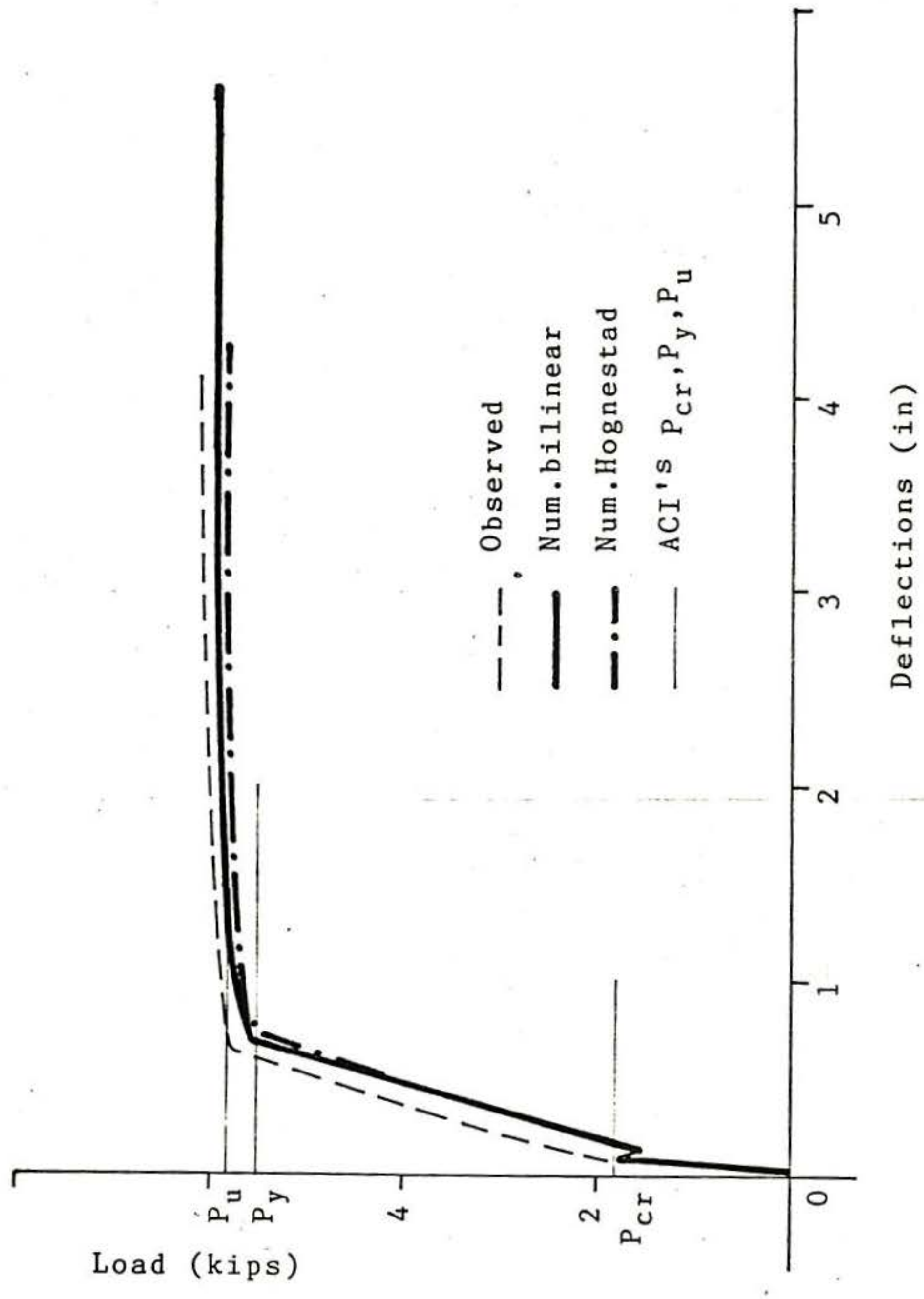
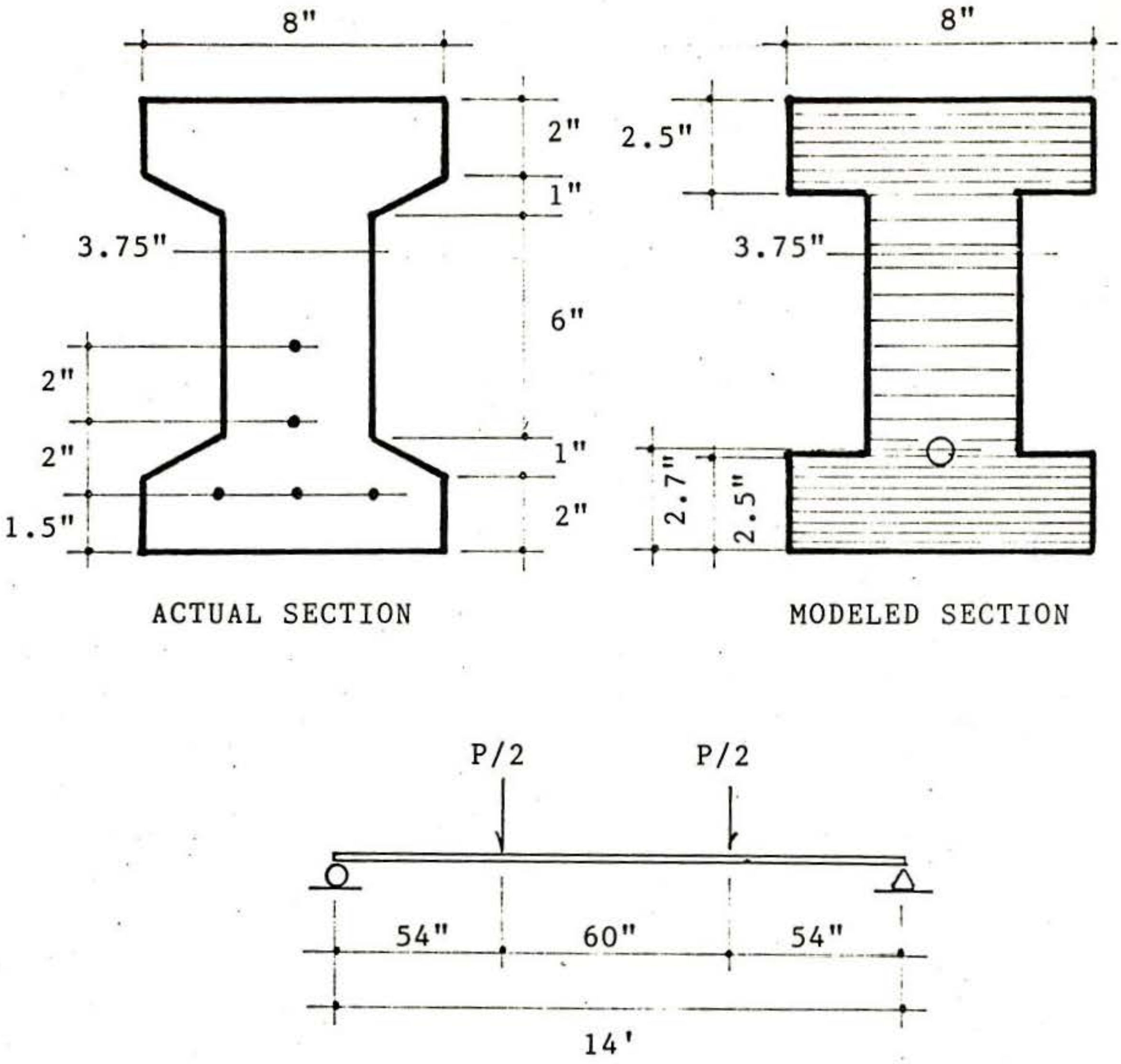
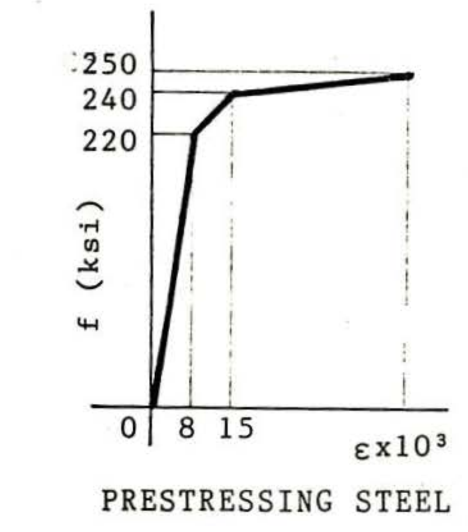


Fig 4.3 - Load-deflection curve for beam Example 4.2.2.





f'_c = 6750 psi

E_{ci} = 3300 ksi

f_t = 616 psi

A_{ps} = .4 in² (5xϕ3/8")

ε_{si} = .00622

F_{si} = 70 ksi

Fig 4.4 - Pre-tensioned beam for Example 4.2.3.

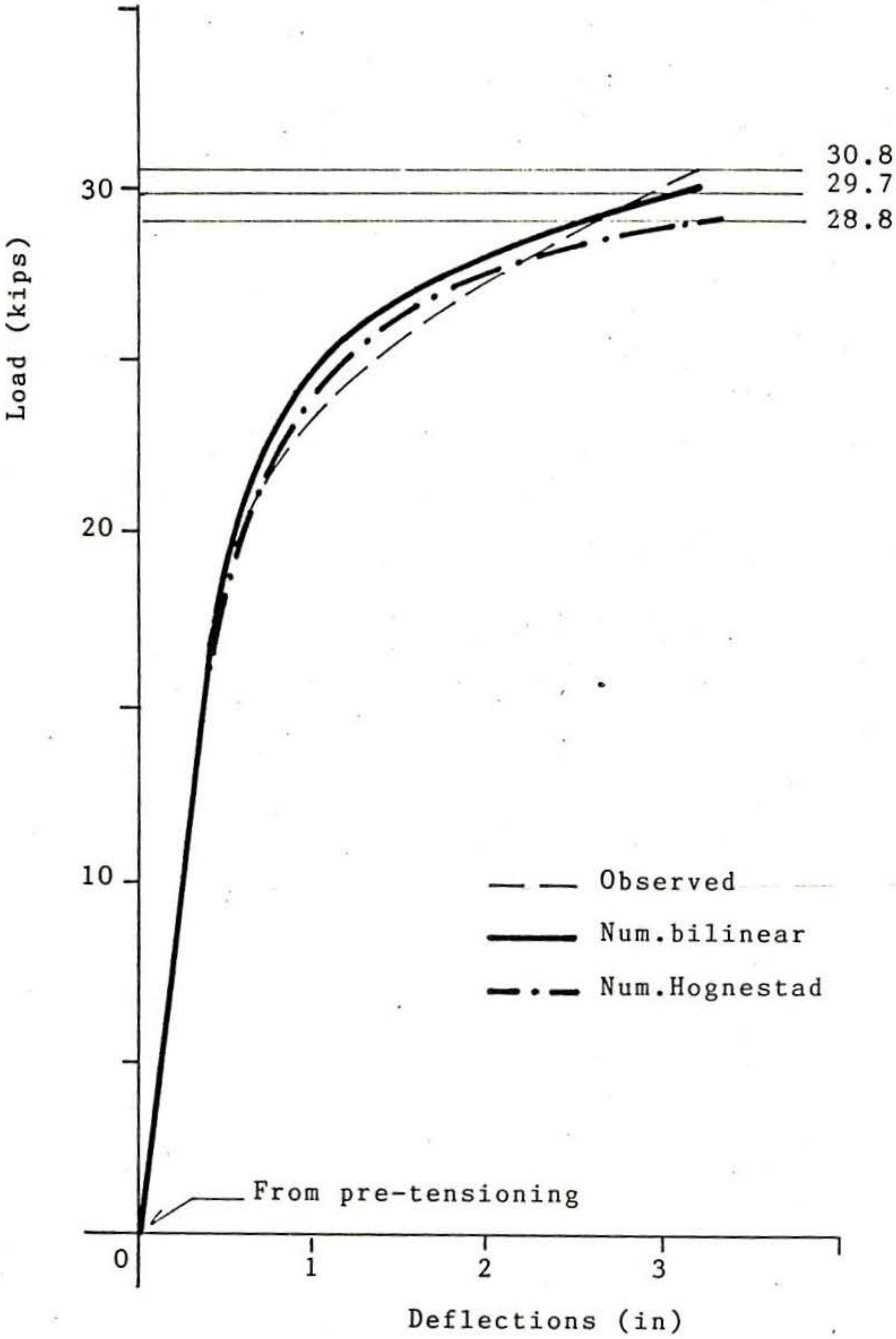


Fig 4.5 - Load-deflection curve for beam Example 4.2.3.

using 11 elements, subdivided into 24 layers. The Displacement Increment Method is used for live load using both the Hognestad and bi-linear stress-strain relationships. The load-deflection curves are shown in Fig. 4.5.

The ultimate loads obtained numerically, by using the two different stress-strain relationships, are respectively 3.6 and 6.5 percent lower than the 30.8 kips. reported by Keyder. In the post-cracking range, the beam appears to be stiffer as predicted by the computer model, which is believed to be due mainly to the sharp tri-linear modeling of the stress-strain relationship for the prestressing steel.

4.3 Instantaneous Response and Strength of Composite Beams

4.3.1 Prestressed Concrete Double Tee Beam

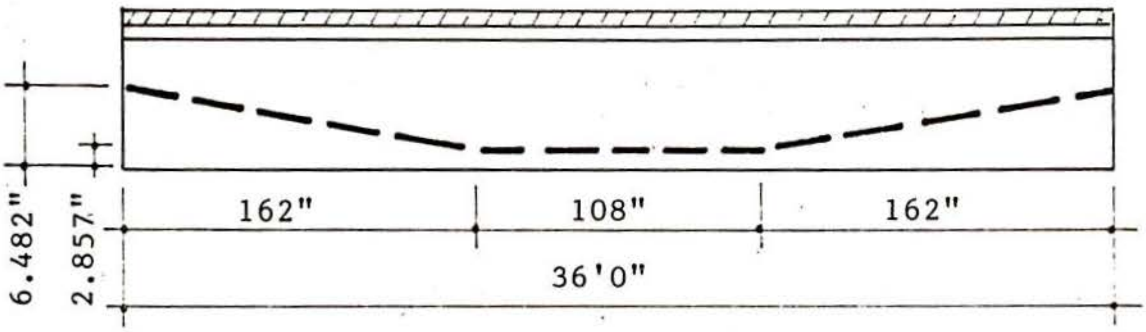
A standard double tee section taken from the PCI Design Handbook (18), with a simple span of 36 ft was selected to test the ability of the program in analyzing the composite beam action. This section was also analyzed by Lo (37), using a modified form of the program developed by Chang (36), as well as by the elastic theory, the effective modulus method and the ACI method for ultimate moment. Since no measurement of the actual behavior of the beam is available, Lo's results will be used to compare with the results obtained from the computer analysis.

The beam is pre-tensioned by two 7-wire strands, 270 K grade, with initial prestressing stress fsi of 189 ksi. At transfer the prestressing stress is assumed to be 0.9 fsi and equal to 170 ksi. Details of the draped cable profile, the cross-section and material properties assumed in the analysis are given in Fig. 4.6. The beam is assumed to be pre-tensioned before the topping is cast. When the topping is cast, its weight is supported by the beam alone. Live load is uniformly distributed over the top surface and applied after the composite action is obtained.

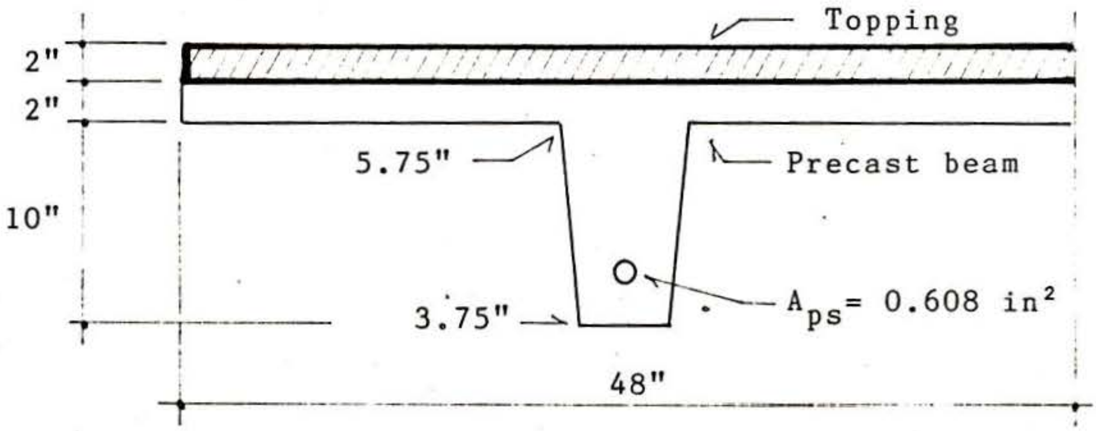
In the proposed analysis a symmetric quadrant of the beam is modeled by 18 beam elements, subdivided into 20 and 5 layers for the beam and topping, respectively. Prestressing and dead loads are applied by using the Load Increment Method, and live load by the Displacement Increment Method, with specified displacement increments of 0.01 in. Both the Hognestad and bi-linear stress-strain relationships for concrete are assumed, and the results are presented in Fig. 4.7.

The load-deflection responses from the computer analysis and from the elastic theory are in fairly good agreement up to the cracking load of the beam. A stiffer beam is predicted by Lo's analysis before the composite action is formed. However, no change in the stiffness of the section is indicated by Lo's results after the development of composite action. Evidently, he has shown the camber for a stiffer section and thus his curve begins with less initial upward deflection prior to downward load application. A slightly higher cracking load is predicted by the computer analysis, as compared to Lo's results and that of the elastic theory, which is probably due to approximation in modeling the section.

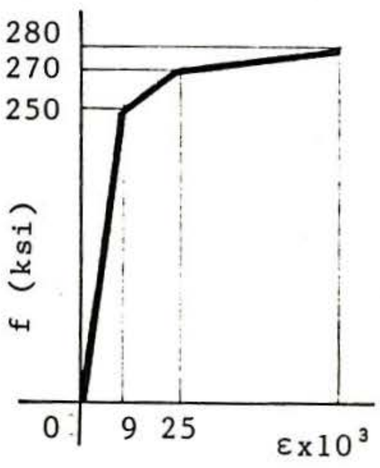
The responses to applied load after the composite action is developed, as represented by both analyses are in good agreement. However, the Effective Modulus of Inertia Method predicts a much less



TENDON PROFILE



CROSS-SECTION



PRESTRESSING STEEL

f'_c= 5000 psi (girder)
E_{ci}= 4290 ksi (")
f'_c= 3000 psi (topping)
E_{ci}= 3320 ksi (")
f_{si}= 189 ksi
(before transfer)
E_{ps}= 27800 ksi

Fig 4.6 - Pre-tensioned composite beam for Example 4.3.1.

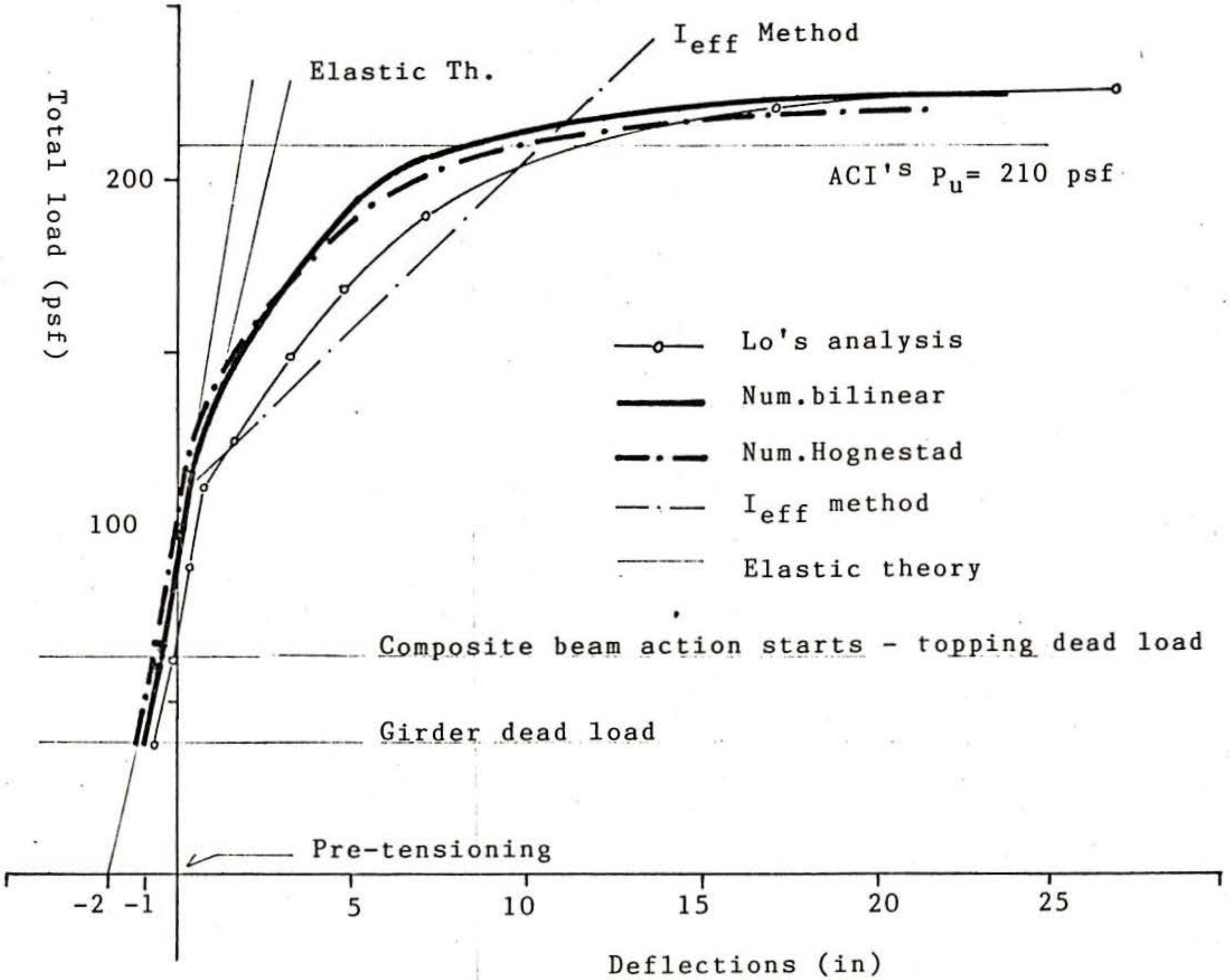


Fig 4.7 - Load-deflection curve for beam Example 4.3.1.

stiff beam after cracking and does not show the ductility of the beam in the range where the prestressing steel yields. The ultimate loads as presented by the different methods are: 227 psf. by Lo's analysis, 225 and 221 psf. by the computed analyses, using a bi-linear and Hognestad's stress-strain relationships, respectively, and 210 psf. by the ACI Method, which are within about 8 percent of one another.

4.3.2 Two-Span Prestressed Concrete I-Beam

From the group of three pre-tensioned composite and continuous beams tested by Wong (38), Beam BS-3 is chosen for validation of the author's program in modeling prestressed continuous beams. The beam was also analyzed priviously by Chang (36).

The beam, as shown in Fig. 4.8, was composed of two standard I-girders, each 15 ft long, and connected by a cast-in-place deck slab with a rectangular diaphragm, positioned over the intermediate support. The girders were pre-tensioned, after that the deck and diaphragm were cast making a continuous beam for live load. Both deck and girders were reinforced with steel bars with yield strength of 60 and 85 ksi. respectively.

The assumed material properties are shown in Fig. 4.8. The computer analysis was performed by modeling one of the spans with 17 beam elements, subdivided into 20 and 10 layers for the beam and deck, respectively. Loading was applied as two concentrated loads, at the center of each span, and the analysis was carried out by the Displacement Increment Method, with specified displacement increments of

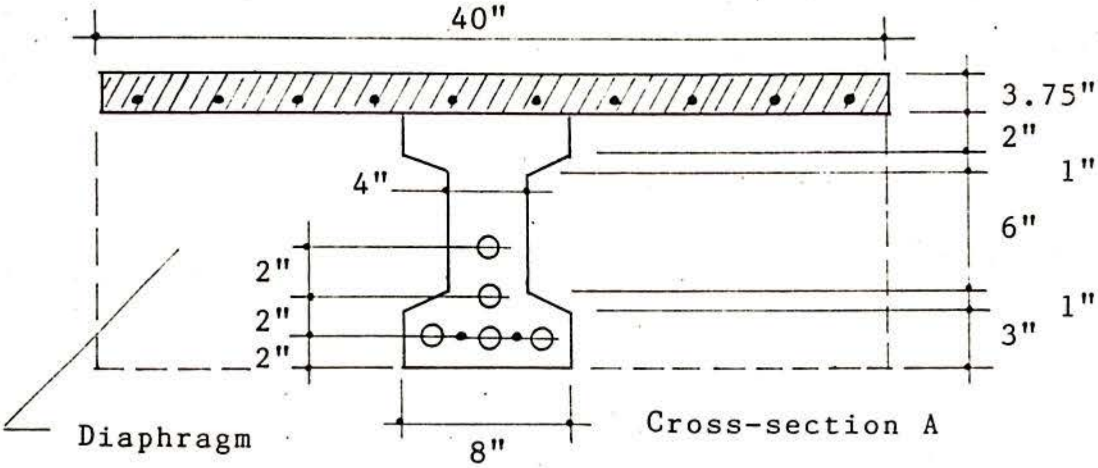
0.01 in. Analysis for the effect of prestressing, however, was obtained by using the Load Increment Method.

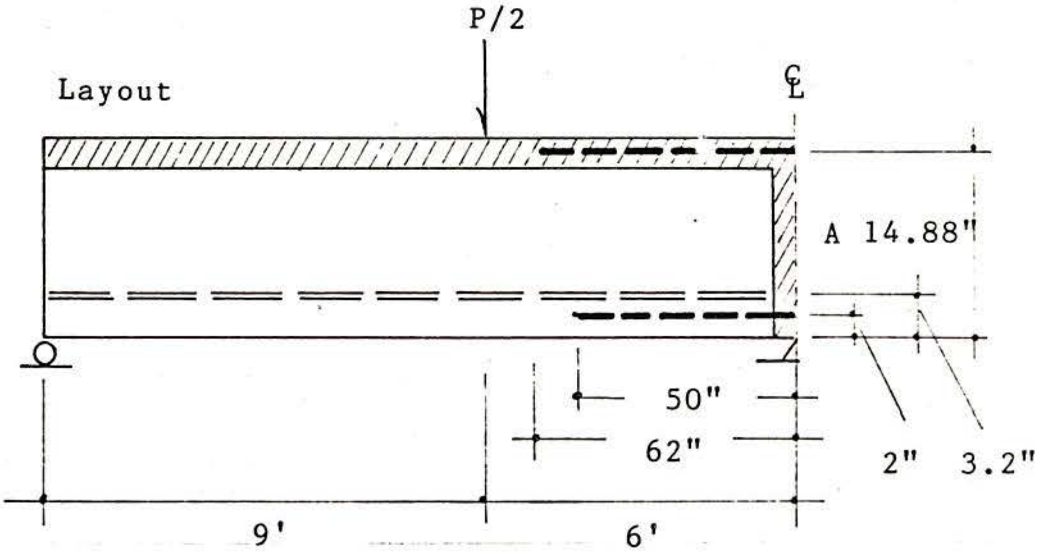
The general shape of the load-deflection curve, shown in Fig. 4.9 for the mid-span deflection, is in good agreement with the observed results, although the beam seems to be somewhat stiffer up to near the ultimate range based on the computed results. This stiffer response may be attributed to the early occurance of cracking in the deck slab near the intermediate support. This cracking is not evidenced in the analytical curve by the sudden drops characteristic of cracking development. Flexural cracks due to positive moment, evidenced in the analytical curve by the first drop at a load level of 54 kips., are however in good agreement with the observed results. The ultimate loads obtained by using a bi-linear and Hognestad stress-strain relationships are 117 and 115 kips. respectively, which are within 7 percent of the observed ultimate load of 123.5 kips.

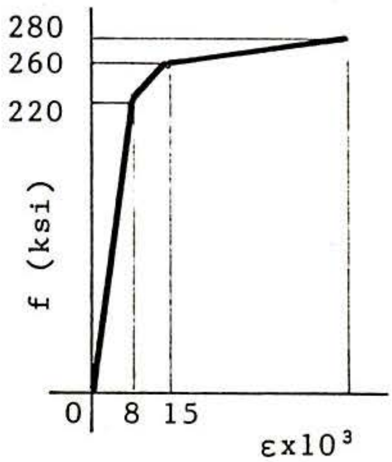
4.4 Time-Dependent Response of Non-Composite Beams

4.4.1 Reinforced Concrete Rectangular Beam

Bakoss, et al [28] have reported the testing for time-dependent effects of four reinforced concrete beams, performed at the N.S.W. Institute of Technology, Sidney, Australia. Two similar one-span beams, designated 1B1 and 1B2, cast with one of the two concrete mixes used, Mix A, are selected for checking the time-dependent response analysis by the author's method. The beams were singly reinforced with two 12 mm bars, at a reinforcement ratio of 0.017, as shown on Fig. 4.10. They were cast and moist cured for 14 days, remaining in a climate-controlled







PRESTRESSING STEEL

$f'_c = 6720$ psi (girder)
$E_{ci} = 3300$ ksi (")
$f'_c = 4410$ psi (deck)
$E_{ci} = 2700$ ksi (")
$A_s = 0.88\ in^2$
$A'_s = 1.80\ in^2$
$A_{ps} = 0.40\ in^2$
$\varepsilon_{si} = 0.00622$

Fig 4.8 - Pre-tensioned composite two-span continuous beam for Example 4.3.2.

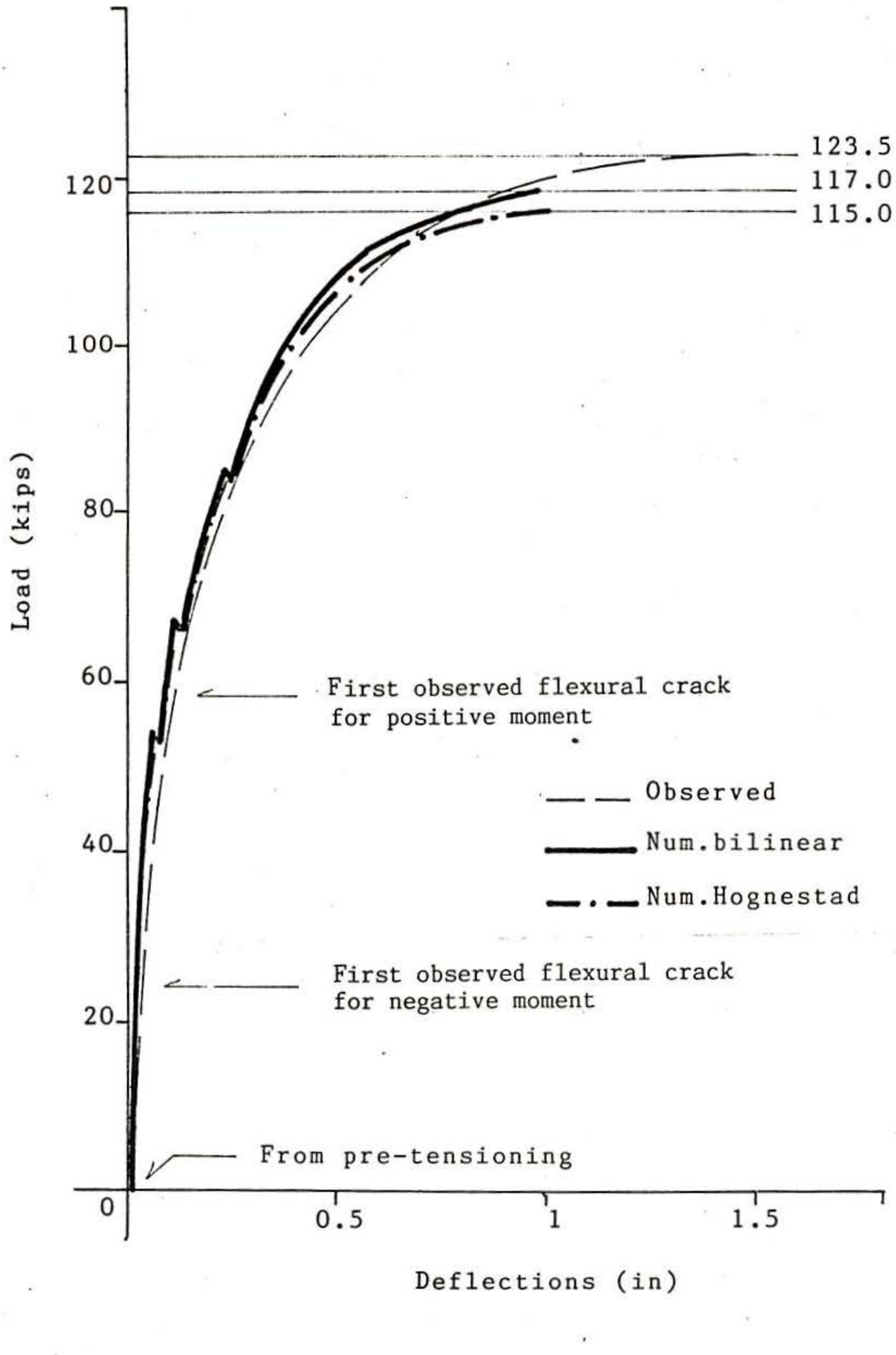


Fig 4.9 - Load-deflection curve for beam Example 4.3.2.

enviroment for the next 14 days, when they were tested under load at 28 days.

As shown in Fig. 4.10, the beams were loaded in their third points, by two concentrated loads of 2.6 KN (585 lb), 45 percent greater than their cracking load capacity. The resulting mid-span bending moment was 62 percent of the calculated moment capacity of the sections. From that time on, the beams were observed for their post-cracking time-dependent deflection up to 500 days.

The effects of creep and shrinkage were observed in a companion beam, with the same cracking pattern as the one under test, but free of loading. The ultimate coefficients for creep and shrinkage, as obtained according to four different codes, vary from 1.4 to 2.8 and 0.0002 to 0.0007, at ages of 600 and 800 days, respectively. The coefficients obtained by following the ACI specifications [56] were 1.5 and 0.0007, which were also used in the numerical analysis.

The beam was modeled by using 9 elements, subdivided into 12 layers, and the time-dependent response under the effects of creep, shrinkage and aging of the concrete was obtained by following the procedure outlined in Section 3.9. Fig. 4.10 shows the comparison of the time-dependent responses obtained experimentally and numerically, by using both assumed stress-strain relationships for concrete. Very good agreement is found concerning the general shape of the response up to an age of 500 days.

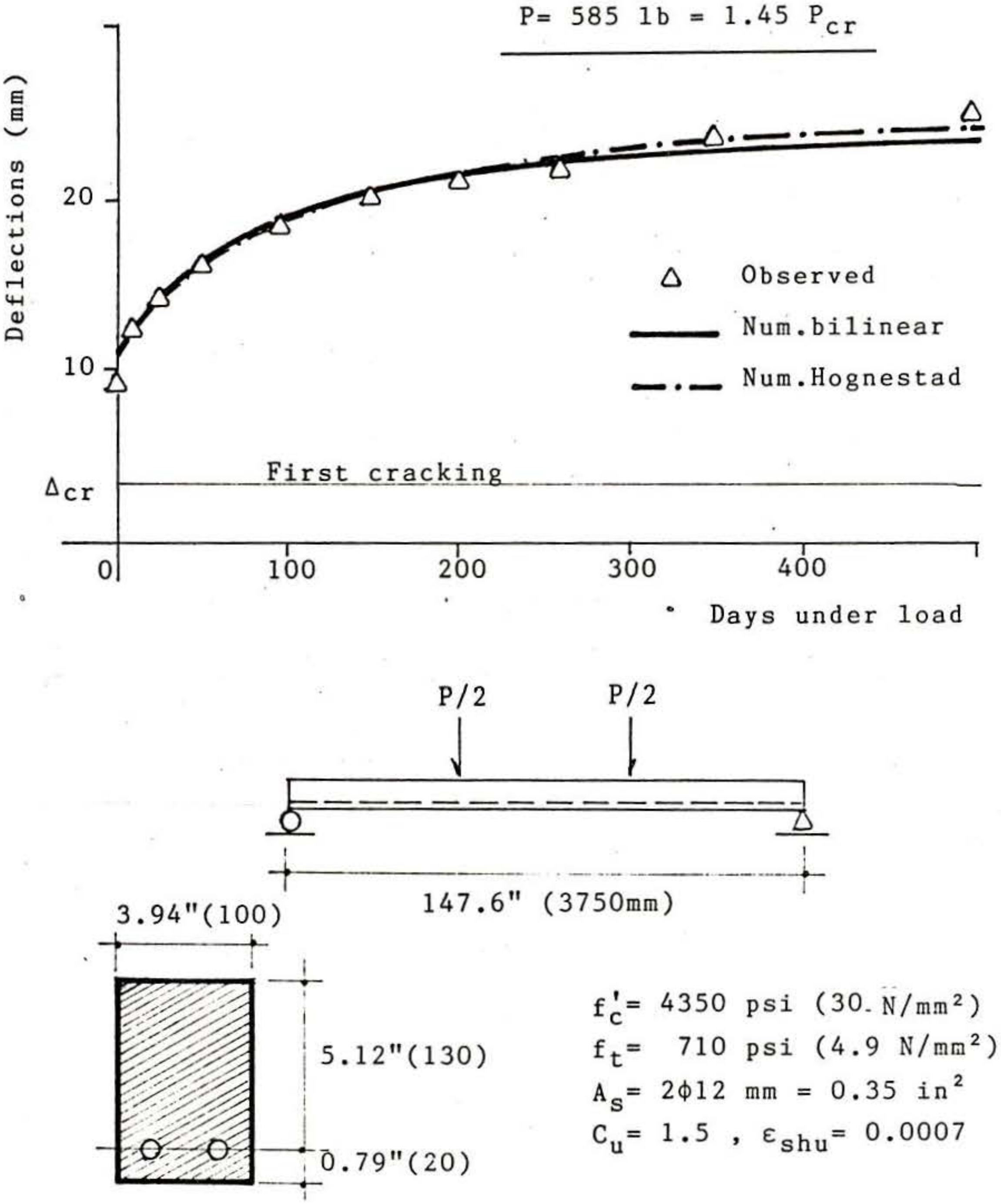


Fig 4.10 - Time-deflection curve, loading arrengement, and cross-section and material properties for beam Example 4.4.1.

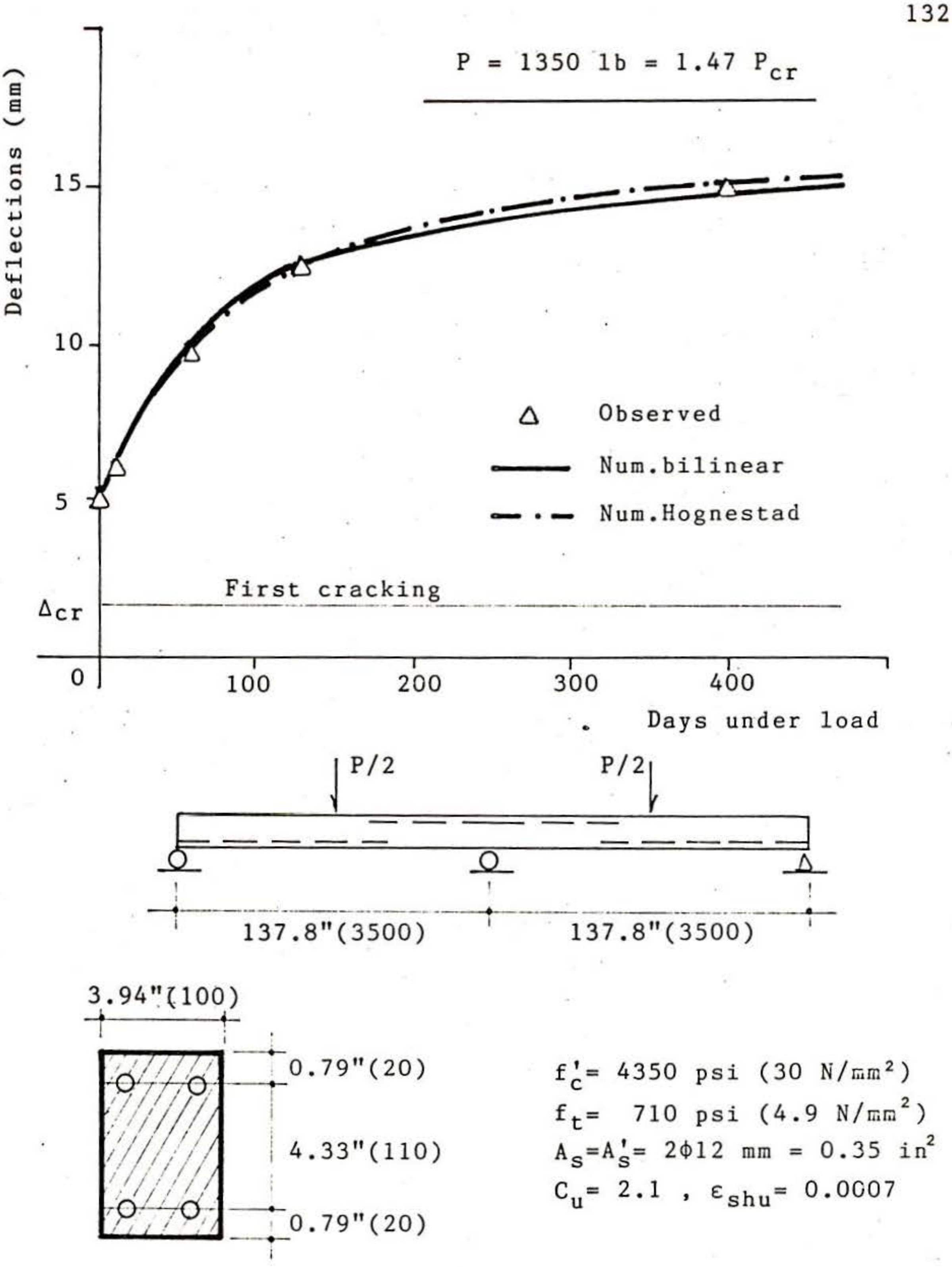
4.4.2 Two-Span Reinforced Concrete Rectangular Beam

In the same work by Bakoss, et al [28], two two-span continuous beams were also tested for their time-dependent response under concentrated sustained loads. These beams had similar charcteristics as the ones discussed above although they were cast with a different concrete mix, Mix B, and reinforced for both positive and negative moments as shown in Fig. 4.11. Two concentrated loads of 6 KN (1350 lb) were applied at the center of each span and the resulting maximum negative moment was 63 percent of the calculated moment capacity of the section, or 47 percent greater then the cracking moment capacity.

The assumed material properties, as listed in Fig. 4.11, were used for the analysis of the post-cracking time-dependent response of the beam, modeled by 12 elements, subdivided into 12 layers, for one span. The observed and computed responses are in good agreement, as seen in Fig. 4.11.

4.4.3 Prestressed Concrete Rectangular Beams

An investigation of the time-dependent responses of non-composite, simply supported and pre-tensioned concrete beams, prior to cracking, was conducted by Zundelevich, et al [65] at the University of Hawaii, in conjunction with the State of Hawaii Department of Transportation, Highway Division. The beams were made of normal and lightweight concretes manufactured with Hawaiian aggregates. Three sets of specimens, made from basalt, cinderlite, and vulcanite aggregates, were used. Each set contained seven beams, three for studying camber, three



$f'_c = 4350$ psi ($30\ N/mm^2$)
$f_t = 710$ psi ($4.9\ N/mm^2$)
$A_s = A'_s = 2\phi 12$ mm $= 0.35\ in^2$
$C_u = 2.1$, $\varepsilon_{shu} = 0.0007$

Fig 4.11 - Time-deflection curve, loading arrengement, and cross-section and material properties for beam Example 4.4.2.

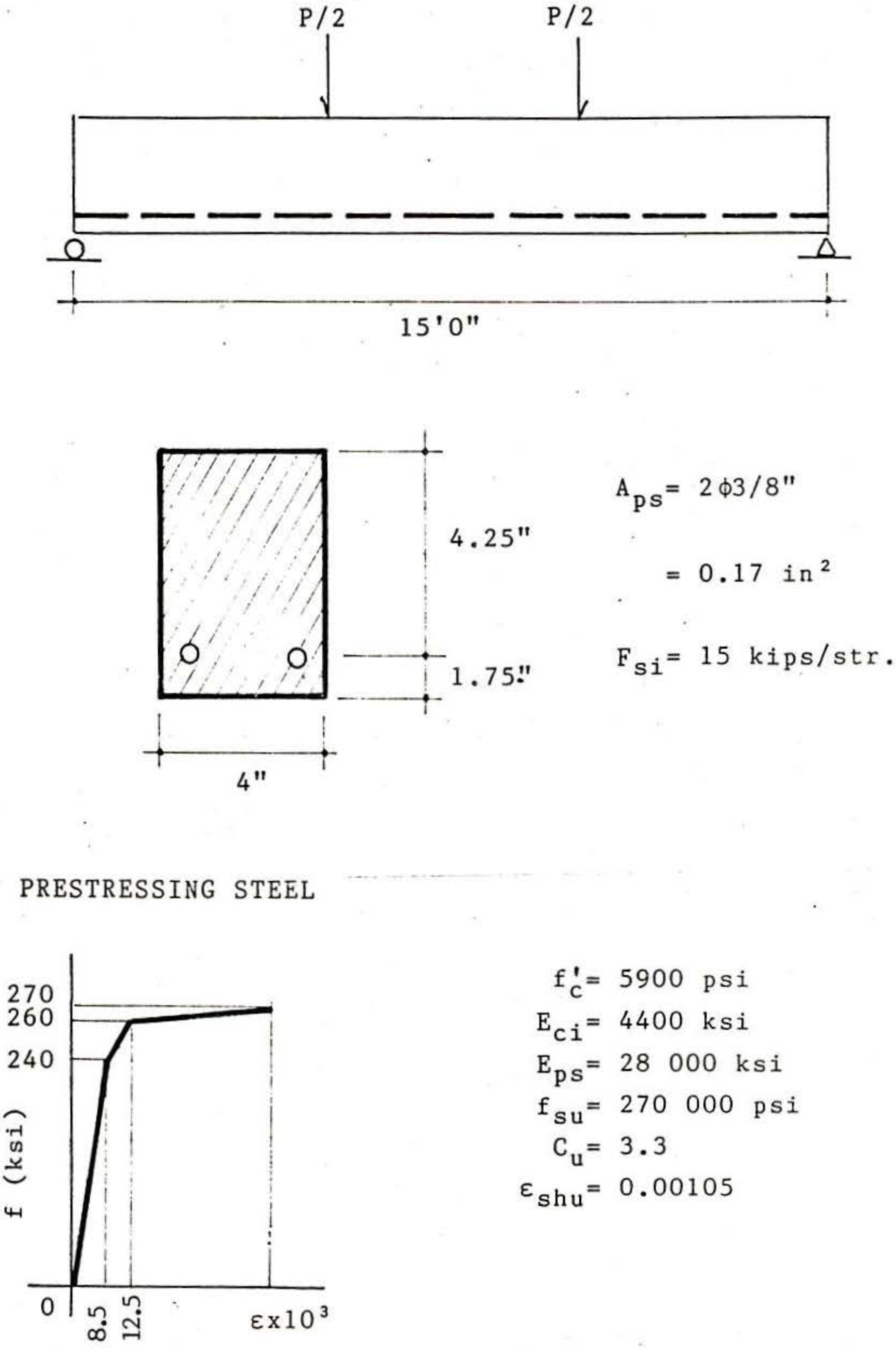


Fig 4.12 - Pre-tensioned beam for Example 4.4.3.

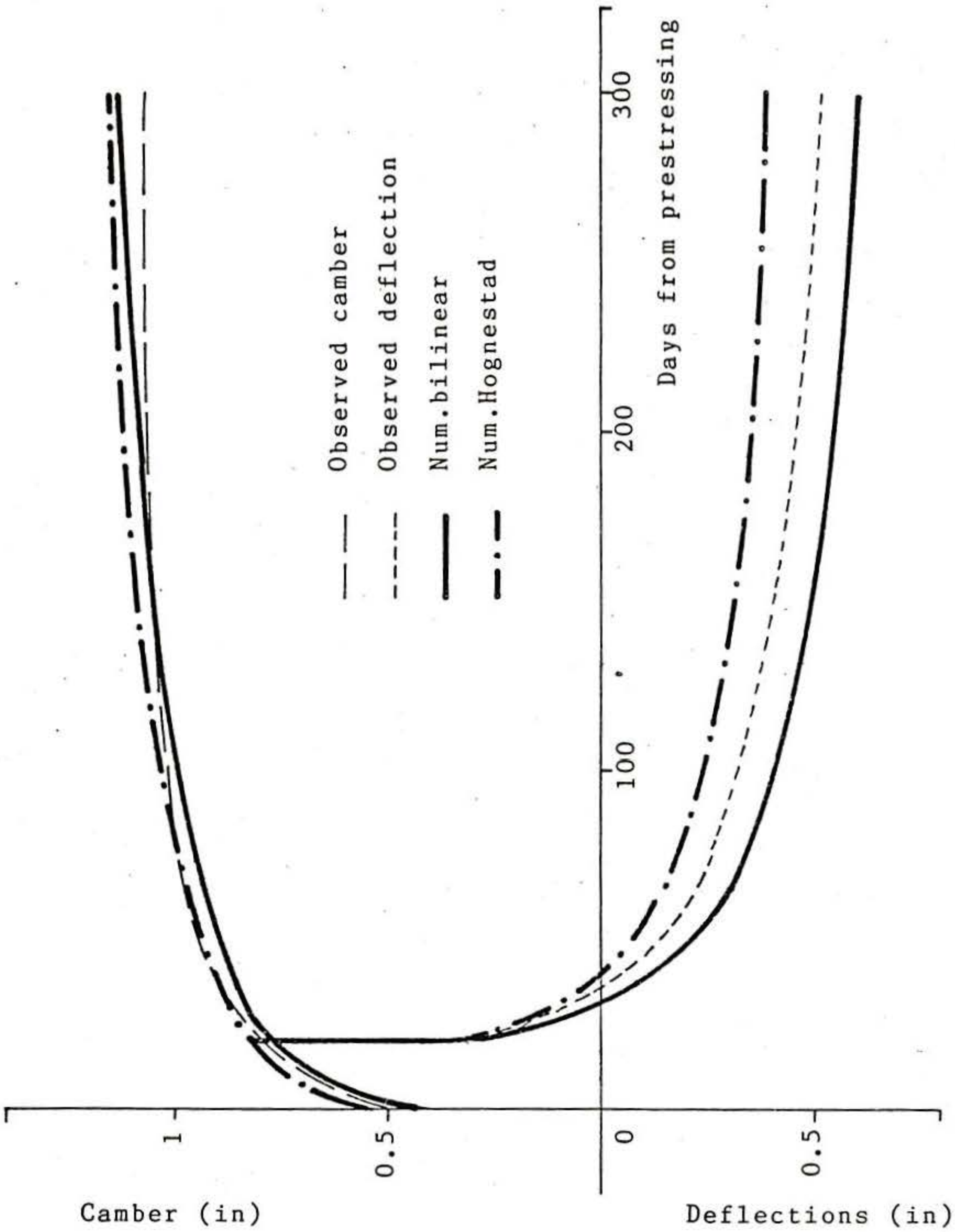


Fig 4.13 - Camber and deflection-time curves for beam Example 4.4.3.

for studying deflection and the other as a shrinkage specimen. The basalt specimens, designated as BEAM1 series, are selected for analysis by the computer program in handling creep recovery under partial unloading of a beam.

The beams were 4 in. by 6 in. in cross-section, and simply supported over their 15 ft span. They were prestressed at the age of seven days by two straight 7-wire strands at an eccentricity of 1.25 in.. The details of the beam and material properties are shown in Fig. 4.12. The camber specimens were observed for camber growth with the beams carrying only their own weight. For the deflection specimens, the beams were loaded at their third points by two 750 lb loads per beam at 21 days after prestressing.

For the computer analysis, one half of the beam was modeled by 9 elements, subdivided into 12 layers. The pre-tensioning effect is obtained by the Load Increment Method, live load application obtained by the Displacement Increment Method and the time-dependent responses by using the Rate of Creep Method and the Superposition Method, as explained in Chapters 2 and 3.

The camber and deflection obtained by assuming both the Hognestad and bi-linear stress-strain relationships for concrete are compared with the observed results in Fig. 4.13. The calculated instantaneous deflections, either for prestressing or for live load, are in good agreement with the observed results. So are the general shapes of the time-dependent responses. Using the Hognestad stress-strain relationship seems to overestimate the camber growth and underestimate the deflection under a creep recovery process. The bi-linear stress-strain relationship gives errors in the opposite sense for deflection, but seems to predict closely the observed camber growth due to prestressing.

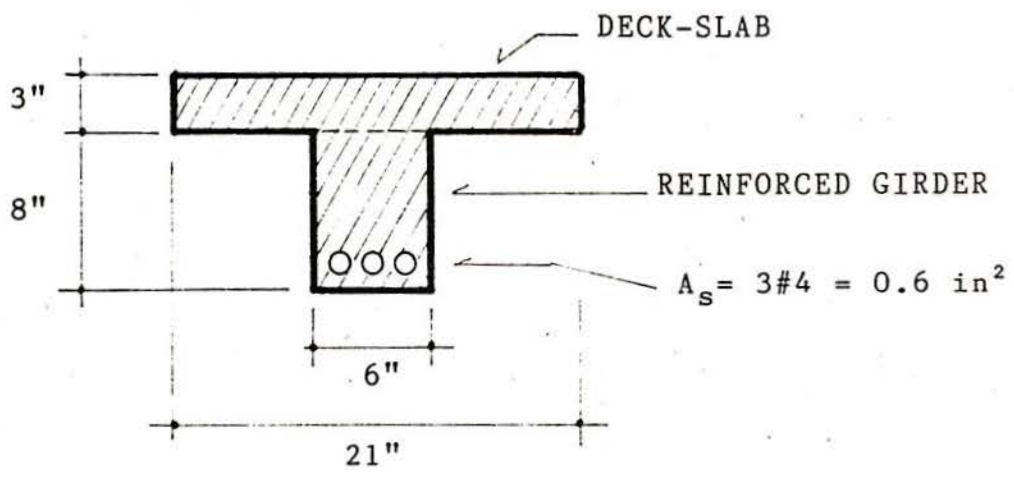
4.5 Time-Dependent Response of Composite Beams

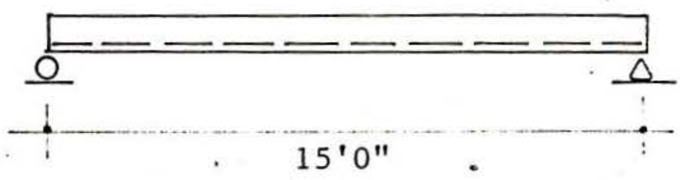
4.5.1 Reinforced Concrete Rectangular Beams

Kripanarayanan and Branson [96] reported studies on the time-dependent behavior of composite reinforced concrete beams, resulted from the age differential between the casting of the beams and the casting of the deck slab. Three simply supported beams, as shown in Fig. 4.14, were cast and tested under the influence of dead load only. One of the beams was non-composite and served as the control specimen for the other two, of which their decks were cast at the age of one and seven weeks respectively after positioning of the beams.

The beams were made of sand-lightweight concrete with a 28-day cylinder strength of 3950 psi, and the decks of normal weight concrete with a 28-day cylinder strength of 4225 psi. All beams were singly reinforced with three #4 bars, having a reinforcement ratio of 0.01667, the deck slabs were not reinforced. The assumed ultimate creep and shrinkage coefficients were 4.0 and 0.0006 for the beams, and 4.0 and 0.0004 for the slabs, respectively.

The beams are modeled for half span by 6 beam elements, subdivided into 12 and 6 layers, for the web and flange respectively. Dead load is applied by the Load Increment Method and the time-dependent response obtained by using the Rate of Creep and Superposition Methods.





$f'_c = 3950$ psi (beam-sand lightweight concrete)
$E_{ci} = 3000$ ksi
$f'_c = 4225$ psi (deck-normal concrete)
$E_{ci} = 3700$ ksi
$f_y = 50$ ksi
$C_u = 4.0$ (beam and deck)
$\varepsilon_{shu} = 0.0006$ (beam)
$\varepsilon_{shu} = 0.0004$ (deck)

Fig 4.14 - Composite beams for Example 4.5.1.

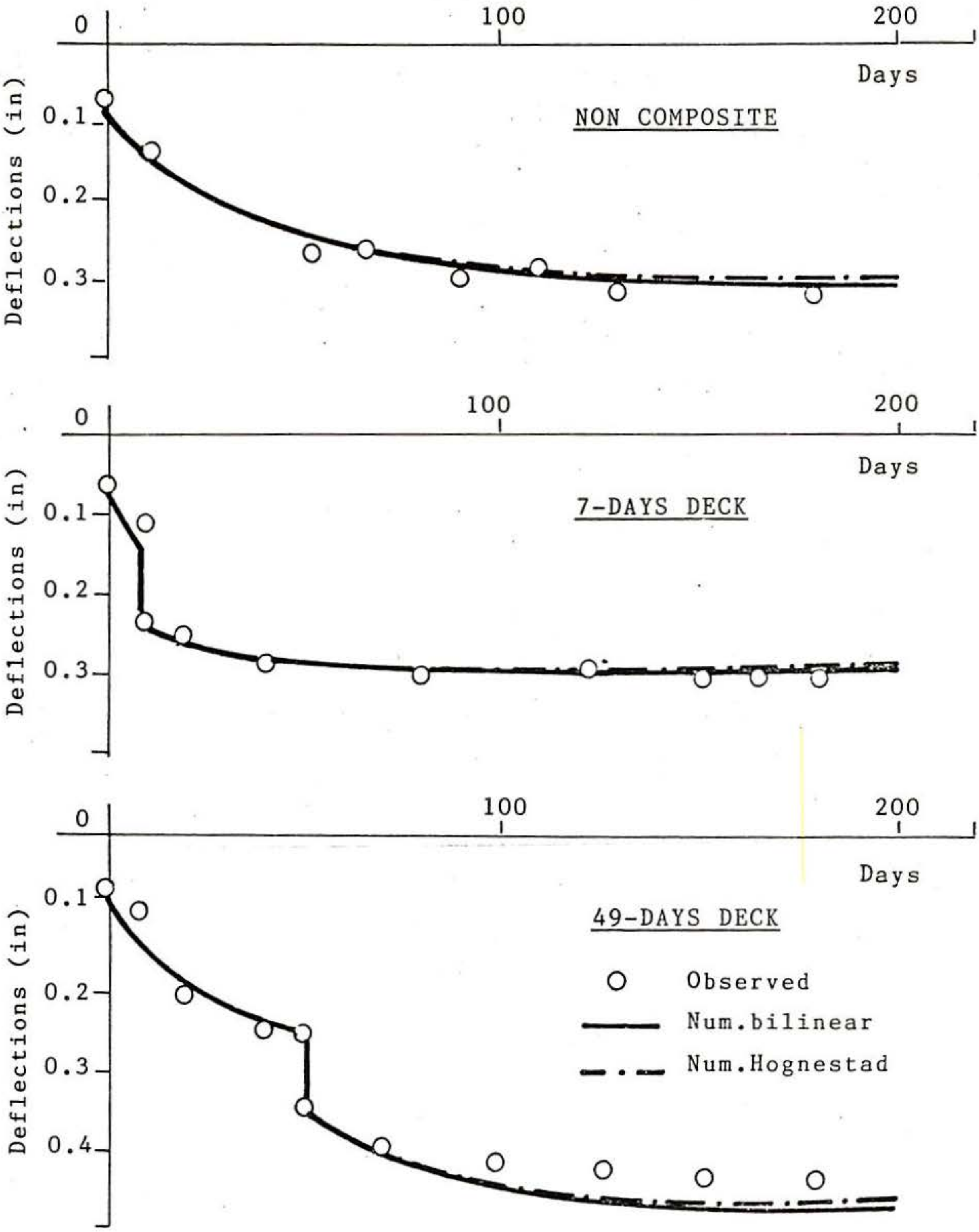


Fig 4.15 - Time-deflection curves for beams Example 4.5.1.

Shown in Fig. 4.15 are the time-dependent responses for the three beams, as obtained from the analysis and compared with the observed data. A very close agreement is obtained by the Hognestad and a bi-linear stress-strain relationships. In addition, close agreement is obtained also between calculated and experimental results. For the third beam, however, the one with the deck cast at seven weeks, the calculated results seem to overestimate the deflection response after about 20 days from the casting of the slab, predicting a final deflection some 10 percent greater than the measured value.

4.5.2 Prestressed Concrete Rectangular Beams

In studying the time-dependent response of composite prestressed concrete beams, Rao and Dilger [21] reported the testing of six one-span simply supported beams, having different reinforcement arrangements and subjected to superimposed sustained live loads.

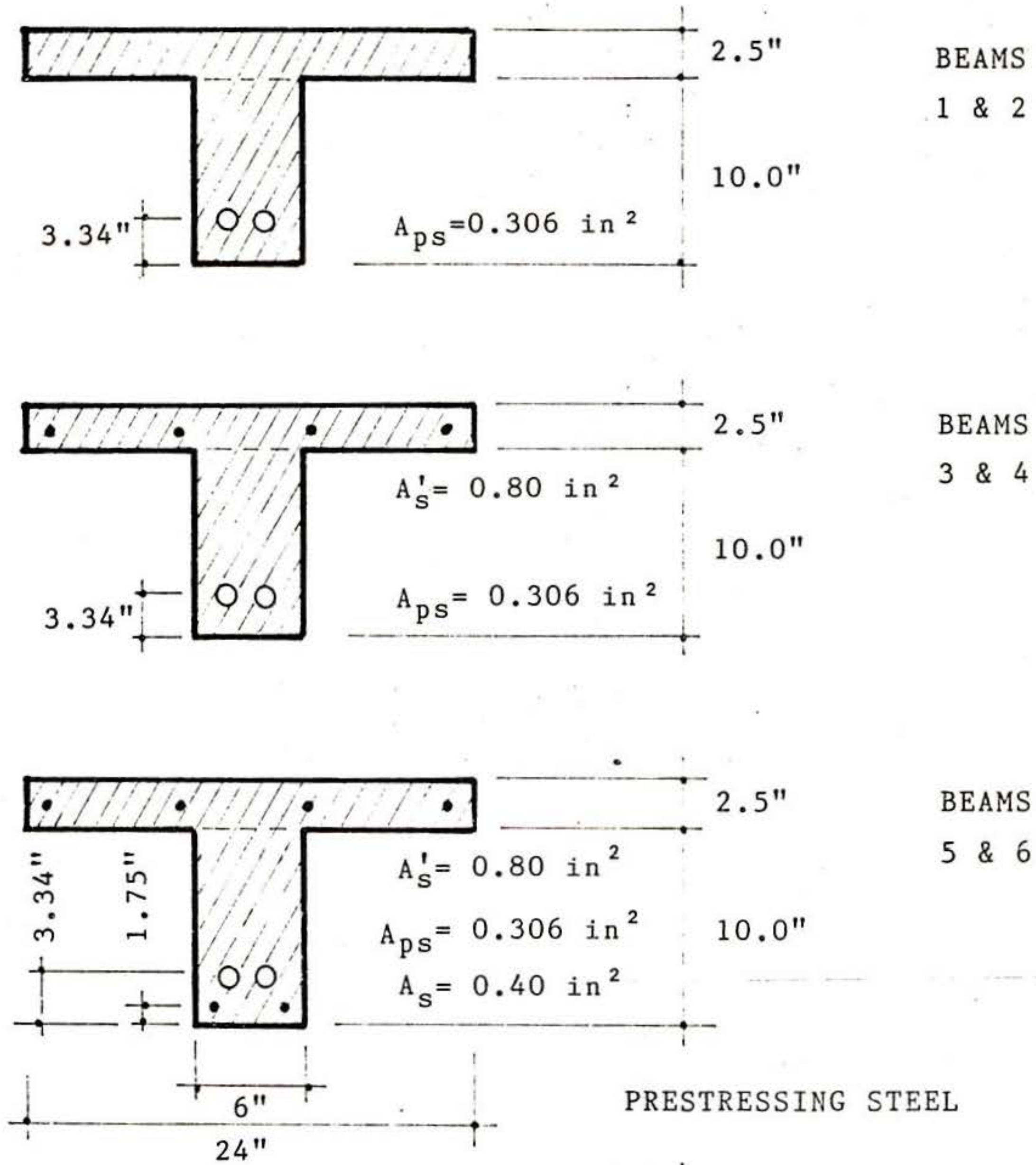
The beams, with the cross-sections shown in Fig 4.16, were numbered 1 to 6. Beams 1 and 2 were pre-tensioned but did not have any mild steel reinforcement. Beams 3 and 4 had an additional deck reinforcement, and beams 5 and 6 also had additional reinforcement in the web. All six beams were 12 ft. long and pre-tensioned by two straight 7-wire strands with an initial total prestressing force of 65.8 kips. The prestressing force was transferred to the concrete seven days after casting. The deck was cast forty one days after the casting of the beam, by using shored construction. Live load was applied on the composite member twelve days after the deck was cast. Two 5.8 kips. concentrated loads were applied at the third points of beams 2, 4 and 6.

The beams are modeled by 12 beam elements, for one half span, subdivided into 12 and 5 layers for the web and top flange, respectively. Prestressing force, dead and live loads are applied by using the Load Increment Method. The assumed material properties are shown in Fig. 4.16.

Since the strands were stressed eight days prior to transferring of the forces to the beams, the initial prestressing force used in the analysis is reduced from the initial force of 65.8 kips to account for the effects of relaxation. The assumed initial prestressing force, obtained by using the recommended PCI equations for loss due to relaxation in stress-relieved steel, given in Section 2.3.2, is 60.5 kips, 8 percent smaller then the previous value.

From the time of prestressing to one hundred and forty days after casting of the beam section, mesurements were taken in the six beams for camber, deflection and curvature of the mid-span section. Figs. 4.17 to 4.20, show a comparison of the observed and calculated results, for curvature in beams 1 and 2, and camber and deflection for beams 1 to 6, respectively.

The use of the Hognestad stress-strain relatioship for the web and deck concrete, shows a consistent overestimate of camber and accordingly underestimate of deflections, as compared to similar results by using the bi-linear stress-strain relationship. The particular shape of the camber- and deflection-time curves for each of the three sets of beams, vary slightly depending on the ammount and position of the mild steel reinforcement. The general trend of the time-dependent responses for all sets of beams are, however, in agreement with the mesured results.



	BEAM	SLAB	
f'_c	6200	4210	psi
E_{ci}	4610	3640	ksi
C_u	1.60	2.48	
ε_{shu}	.000685	.000900	

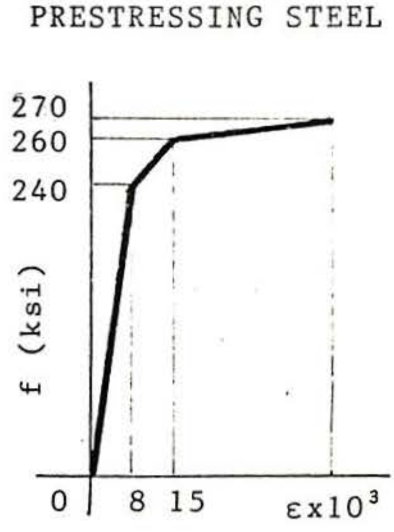


Fig 4.16 - Pre-tensioned beam for Example 4.5.2.

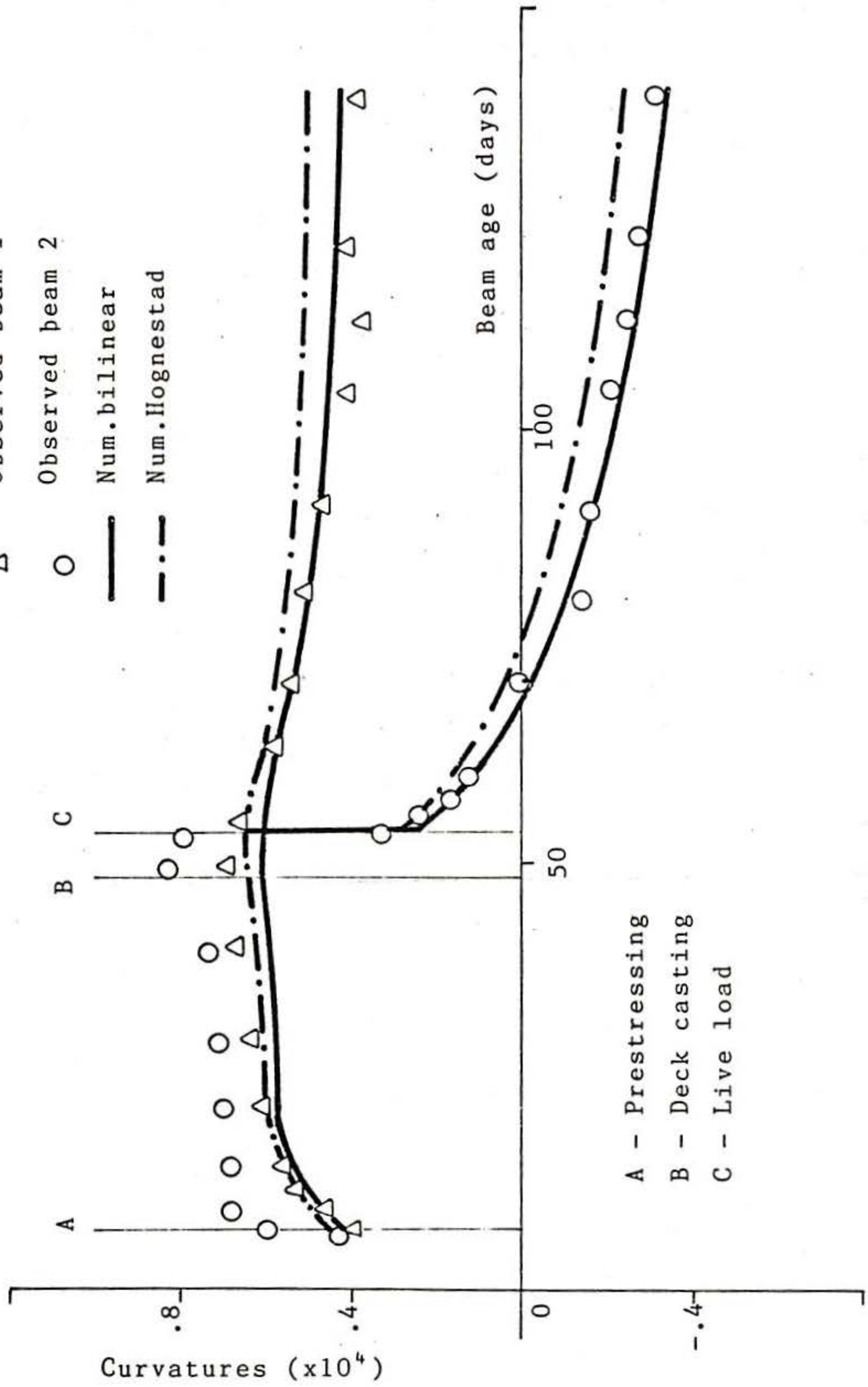


Fig 4.17 - Time-curvature curves for beams 1&2, Example 4.5.2.

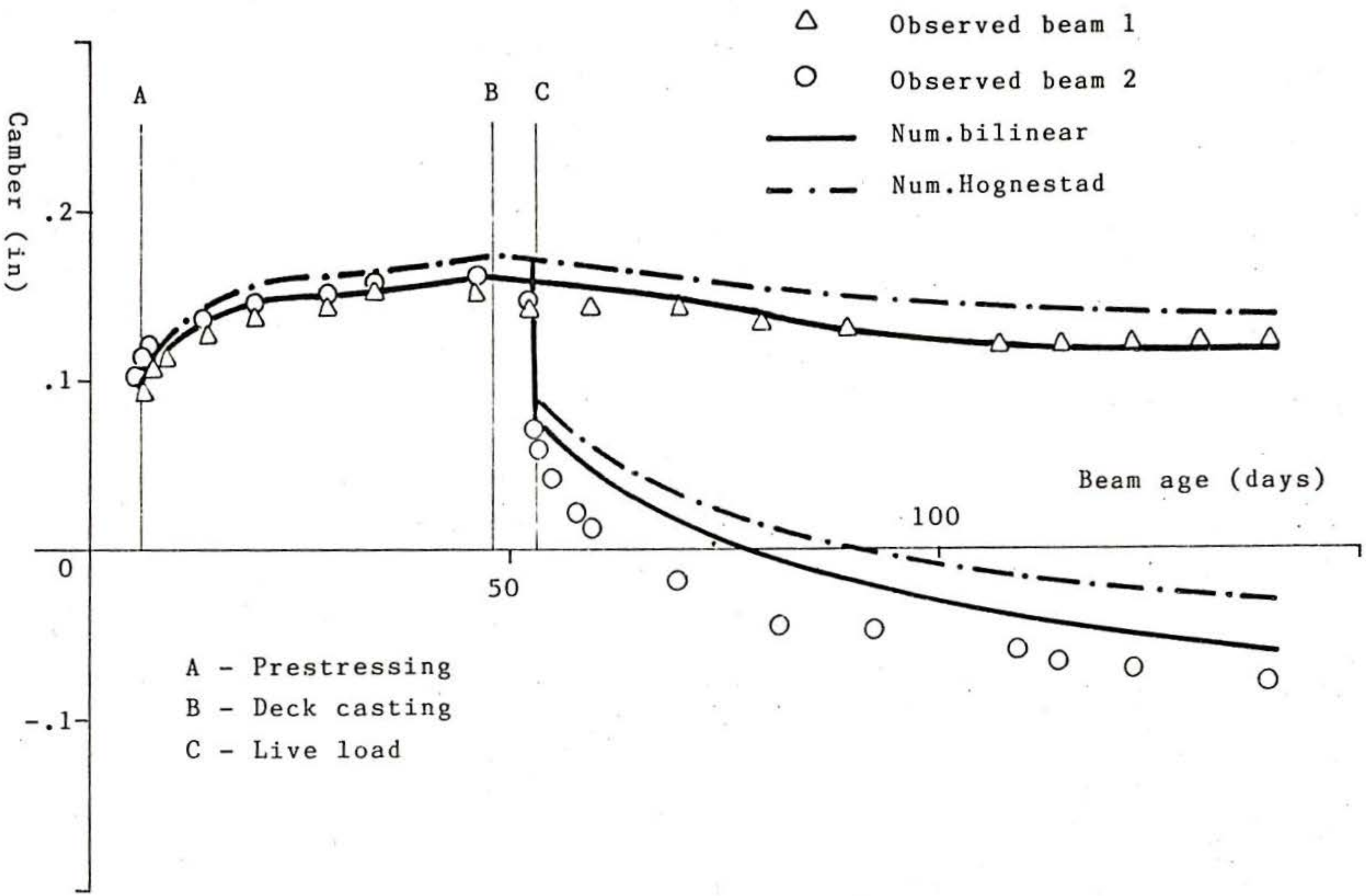


Fig 4.18 - Time-deflection curves for beams 1&2, Example 4.5.2.

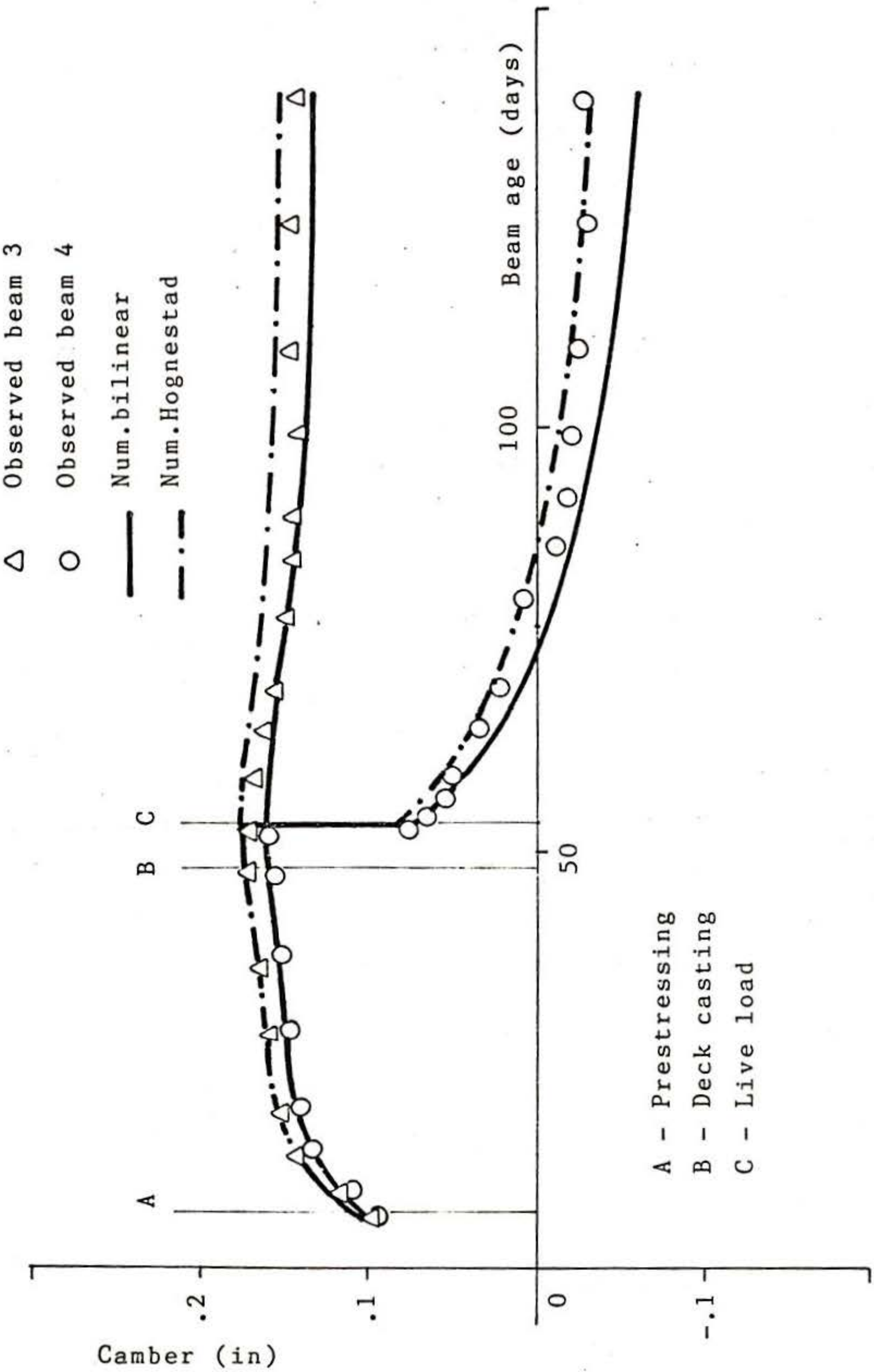


Fig 4.19 - Time-deflection curves for beams 3&4, Example 4.5.2.

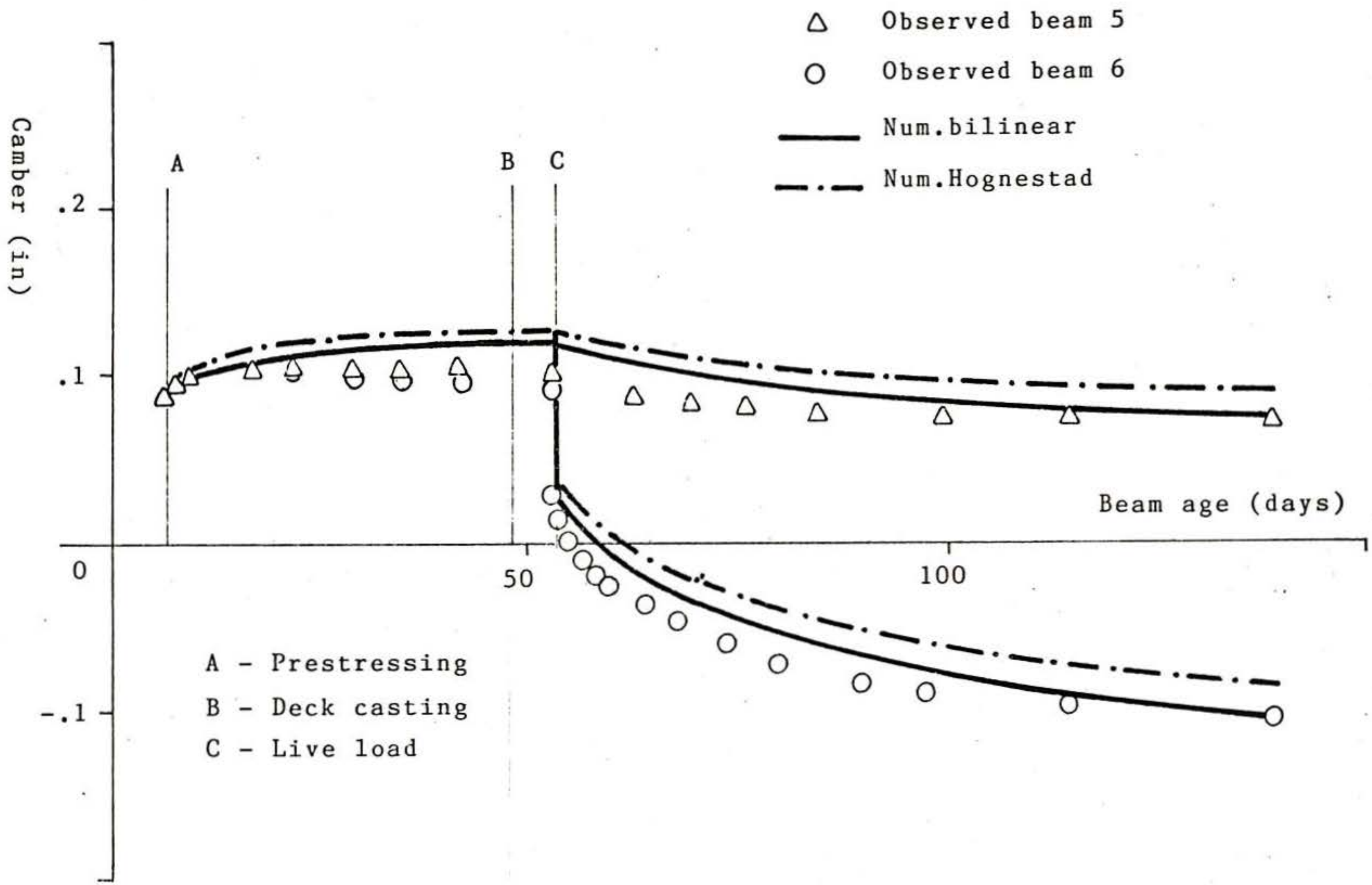


Fig 4.20 - Time-deflection curves for beams 5&6, Example 4.5.2.

5. APPLICATION OF THE ANALYTICAL MODEL TO JOINTLESS BRIDGE BEAMS

5.1 Introduction

Jointless bridge beams may be considered as a solution for the persistent problems caused by the insertion of joints in multi-span bridges. The elimination of joints may be achieved in several ways:

(a) By using a fully-continuous beam, for deck and girders, (FCB).

(b) By casting a continuous deck and a connecting segment or diaphragm between two simple beams over each intermediate support, to develop continuity for carrying live load, (FCLL).

(c) By casting a fully-continuous deck slab over the simple span non-continuous girders, (FCD).

Fully-continuous beam has generally established an excellent performance record. However, it is not as widely used as beams of simple span. Beams made continuous for live load have proven suitable for precast concrete construction and show remarkable performance as far as continuity is concerned when compared to fully-continuous beams. Nevertheless, they may not be adequate for the case of steel girders which are usually constructed as simple span beams with joints being formed at the deck.

A simpler and thus more economical option is to connect simply supported girders through a fully-continuous deck (FCD), with no continuity between the adjacent girders. Being also suitable for precast construction and complying with the join-free idea, they appear to be an alternative solution to one of the severe bridge maintenance problems. Beams with continuous deck provide a simple and efficient solution not only for the construction of new bridges but also for the rehabilitation of old ones, by re-decking the still serviceable simply supported girders.

For beams in which continuity is obtained only through the deck, conventional analytical techniques are inadequate since they are based on the concept of full continuity of the beams. The numerical solution developed in this study, nevertheless, can adequately handle such unconventional cases and, due to its versatility, investigate all the different situations described previously.

In the following sections, two commonly used structures for mid-size span bridges over highway intersections will be analyzed, and comparisons will be made for different situations of loading, continuity and supporting conditions. In Section 5.2, a 100 ft two-span bridge with steel girders will be considered and in Section 5.3, a 264 ft four-span bridge with prestressed girders of equal and unequal spans will be analyzed.

5.2 Analysis of a Jointless-Deck on Two-span Beam With Steel Girders

5.2.1 General Behavior

Shown in Fig. 5.1 is a two-span bridge with two fifty feet W33x118 steel girders supporting a 7 ft by 7 in reinforced concrete deck slab [93]. Three different construction details are given in Fig. 5.2, namely: fully-continuous, deck-continuous and non-continuous. The

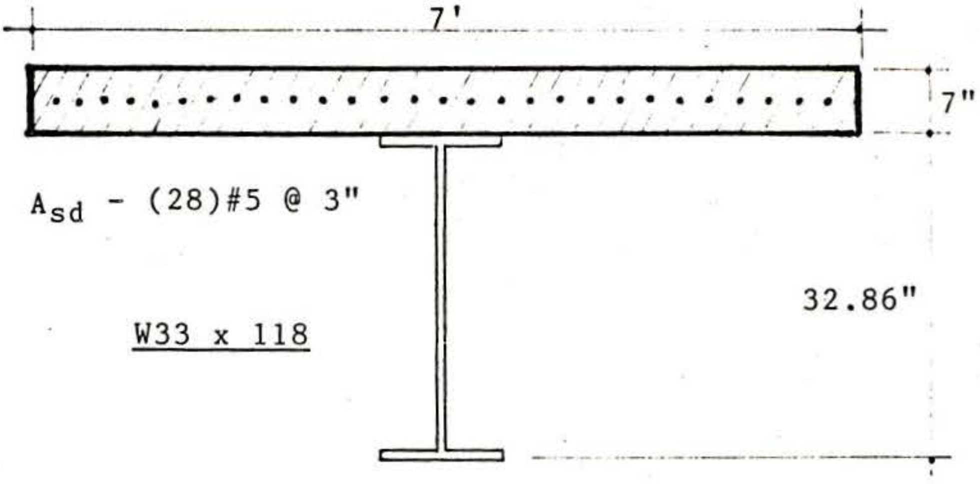


Fig 5.1 - Cross-section.

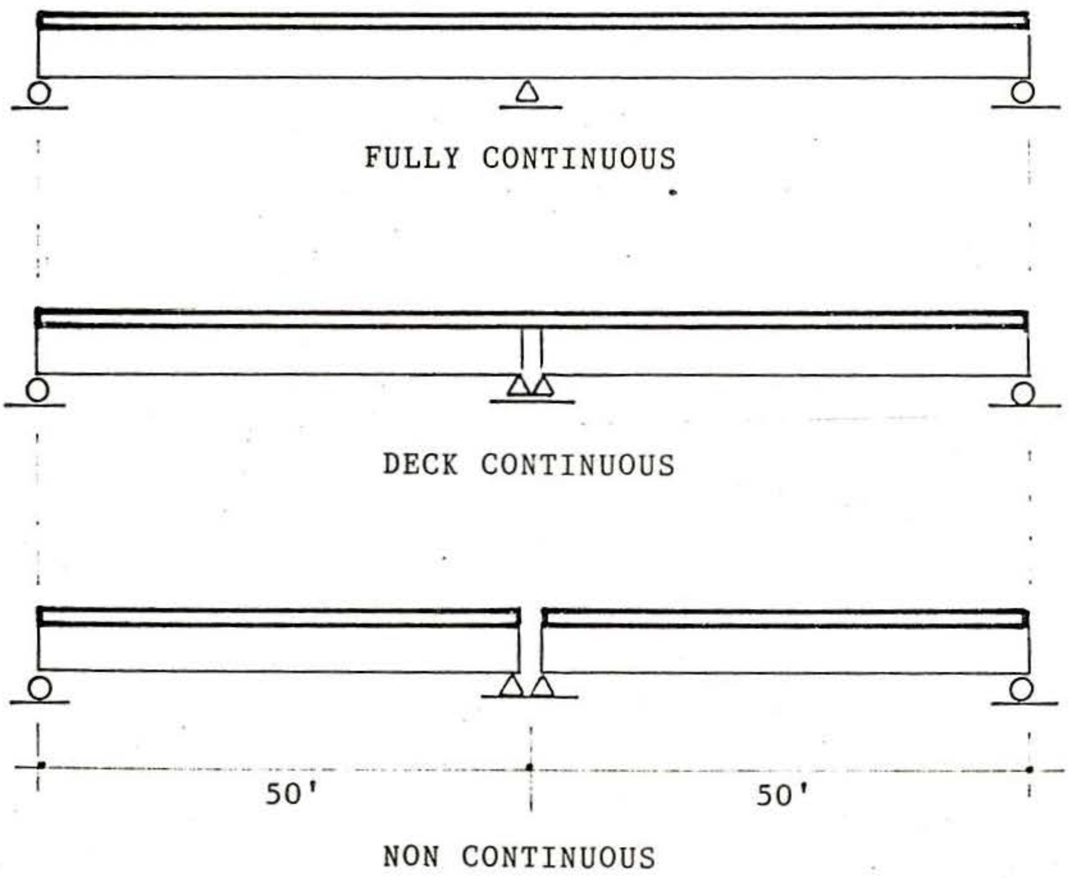


Fig 5.2 - Two-span composite beam with steel girders.

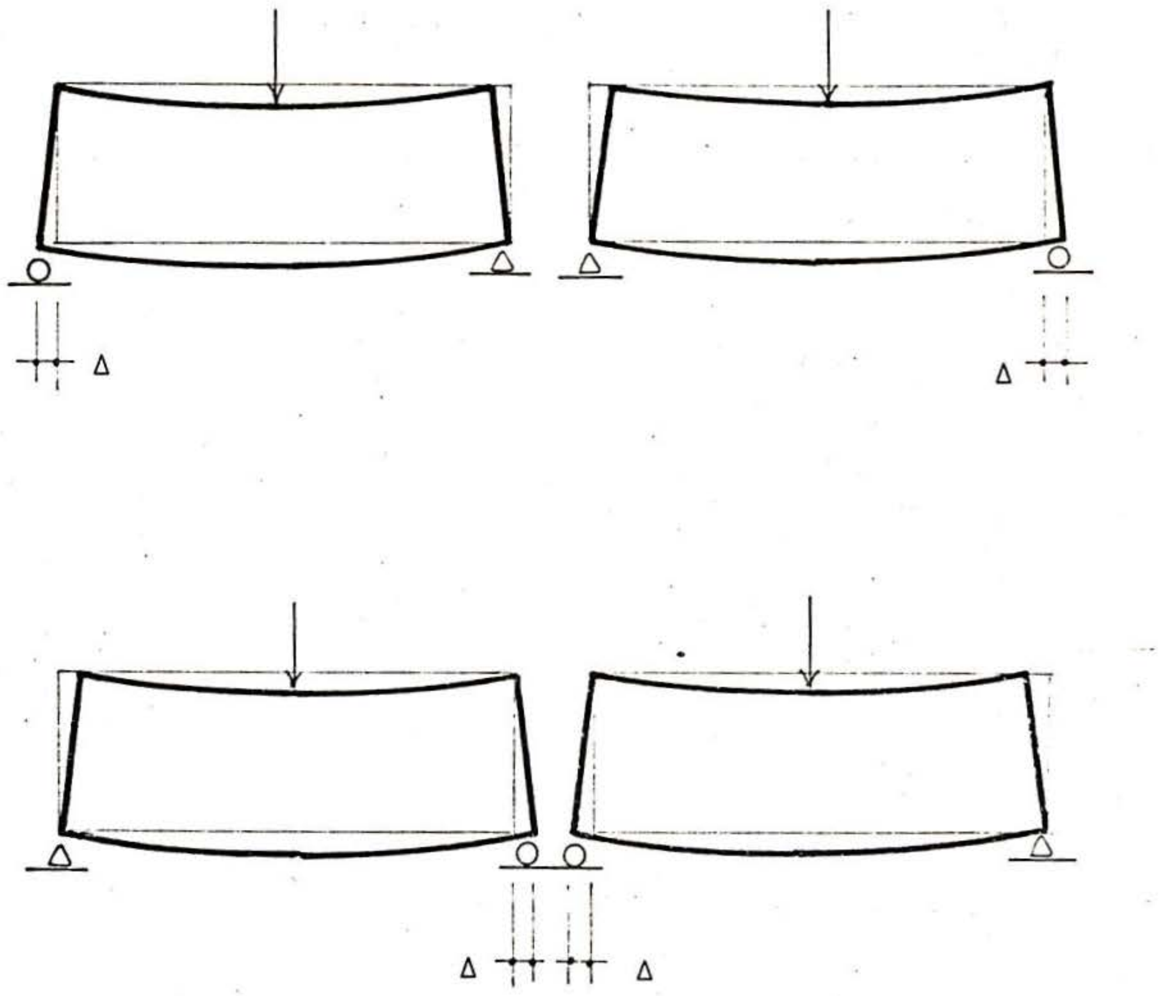


Fig 5.3 - Horizontal movements for different supporting conditions.

performance of these three types of design will be analyzed and compared.

The steel girders are placed into position over the supports, and the concrete deck is cast, either by shored or unshored construction. Supports are provided at the bottom flange of the respective girders, and assumed as hinges, preventing any horizontal movement, or as bearing pads, allowing for some horizontal displacements. Bearing pads are designed according to the procedures outlined in Section 2.4.

When hinges are used, it is assumed that free horizontal movement of the supports is possible only under the action of girder dead load. Horizontal movement of the supports is considered to be restricted for all other superimposed loads on the girders. This supporting condition allows for a more realistic modeling of the structure, since horizontal reactions at the hinges, if any, only appear under the action of live load, or any loading condition following the setting of the hinged supports. The existence of horizontal reactions in the restrictive supports, as well as the force built-up in the deck connection are taken into consideration in the analysis. Should the supports be located at the centroidal plane of the sections, as commonly assumed in basic structural analysis no restricting forces would be generated even if the horizontal movements are prevented.

The deck connection over the intermediate supports is, under any applied loading, subjected to bending and axial force. As shown in Fig. 5.3, depending on the type and arrangement of the supporting conditions, tension or compression may occur at the deck connection, producing a different behavior of the whole structure for each supporting condition.

A numerical analysis is performed by using the Load Increment Method for girders subjected to its own dead load and deck dead load. After composite action is established the beams are analyzed for an increasing uniformly distributed live load up to failure, by using the Displacement Increment Method. Both spans are divided into 12 equal elements, subdivided into 18 and 12 layers for the girders and deck respectively. A connection element is provided when there is deck continuity.

Figure 5.4 shows the load-deflection responses for the deck-continuous beam under different support arrangements, and comparison is made with the extreme cases of a fully-continuous beam and a non-continuous beam. It is assumed that the beams are unshored during the deck construction, and bearing pads are provided at all non-hinged supports. It is interesting to observe that the different beams present a remarkably different behavior, depending on the boundary conditions. Nevertheless, all cases fall within the upper and lower bounds, i.e. fully-continuous and non-continuous cases. The beams in cases 3, 4 and 5, for which a tensile force occurs in the deck connection, behave quite similarly to a non-continuous beam but with slightly less deflections and much less ductility. The maximun load capacity would be governed by yield of the reinforcing steel (assumed at a limiting strain of 1%) in the deck connection.

A compressive force is encountered at the deck connection for the beam in case 2, which yields a much lower moment carrying capacity and ductility, allowing failure to occur by crushing of concrete at the bottom face of the deck. Under loading on one span only, however, as shown in Fig. 5.5, a tensile force is transmitted through the

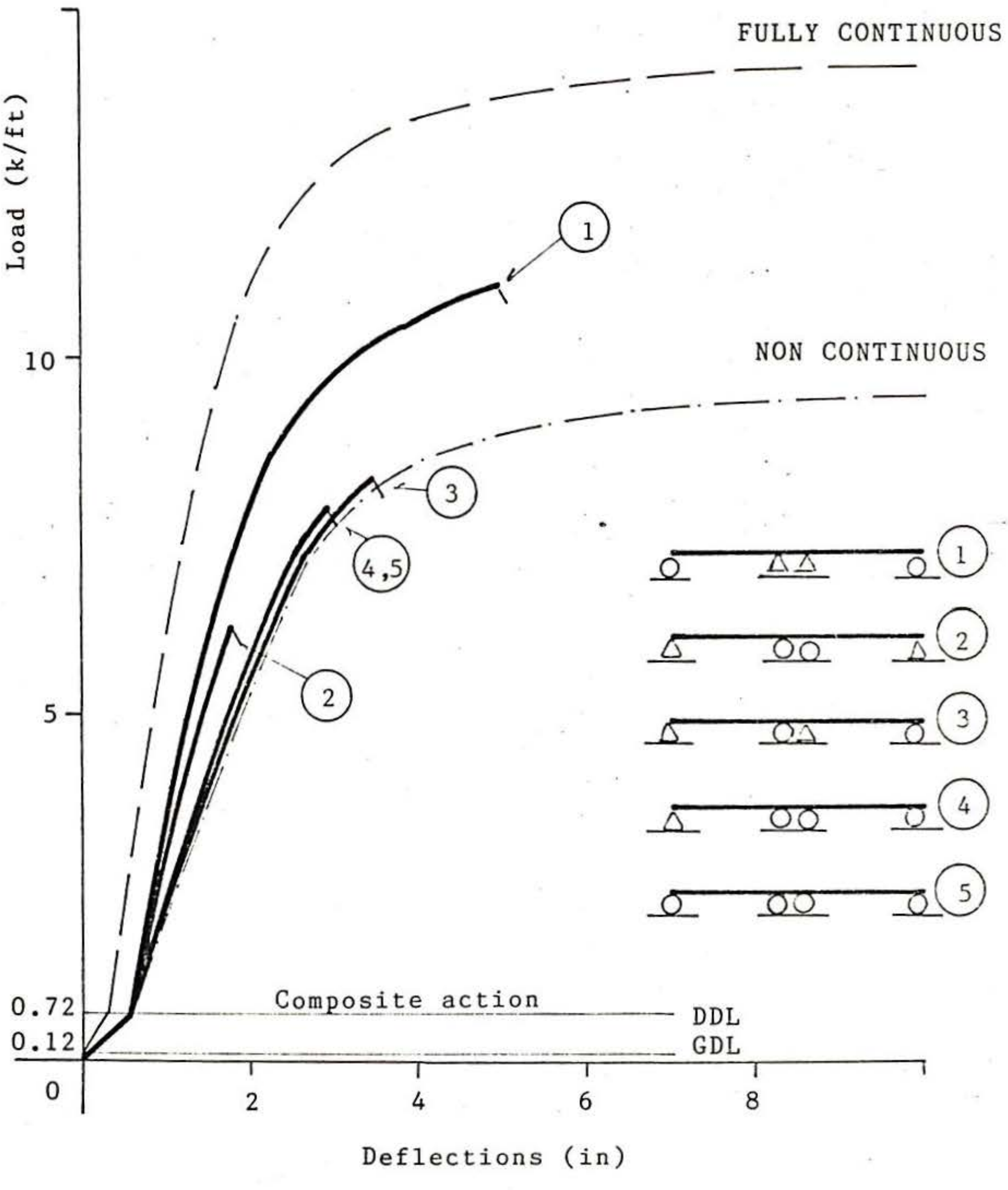


Fig 5.4 - Load-deflection responses under full span loading for various support arrangements. Unshored deck construction.

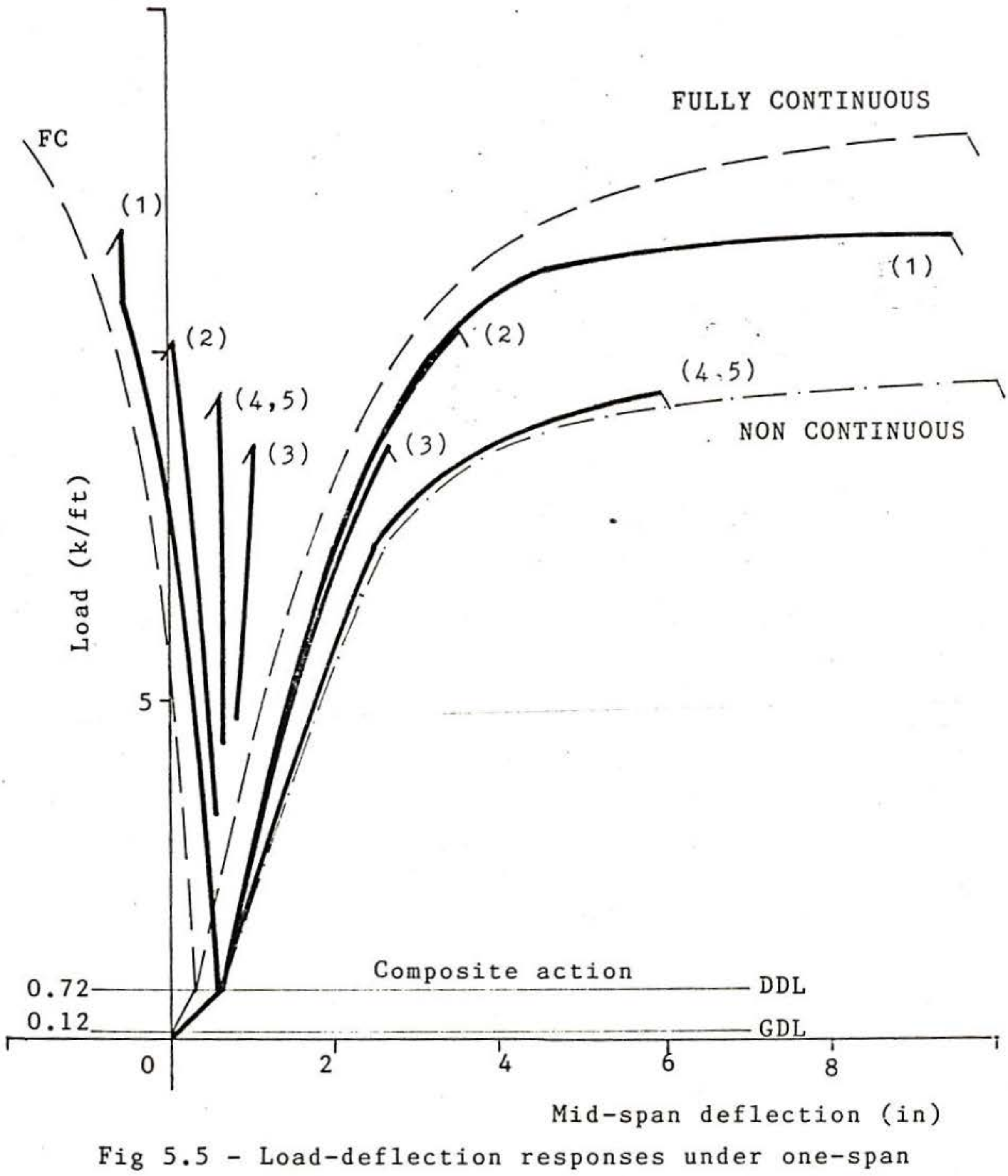


Fig 5.5 - Load-deflection responses under one-span loading. Deflections of both spans for all cases in Fig 5.4.

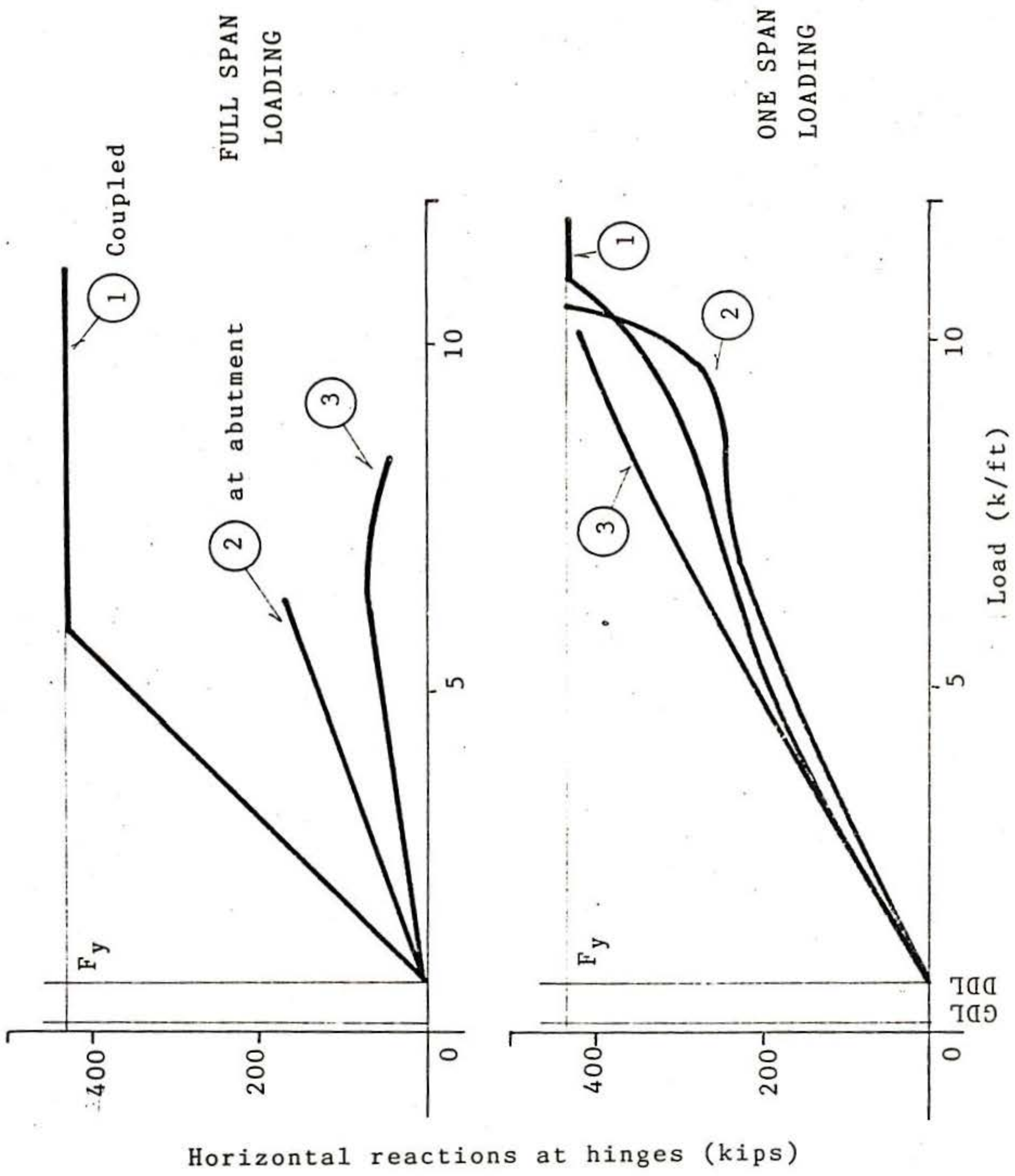


Fig 5.6 - Horizontal reaction build-up for cases in Figs 5.4 and 5.5.

connection, thus enhancing its performance in deflections and strength.

The beam Case 1, having hinges at the intermediate supports, which assure a thorough tensile behavior of the deck connection, performs remarkably better than the beams of all other cases, under either symmetric or unsymmetric loading. Deflections at the service load range are comparable to the case of full continuity, as seen in Figs. 5.4 and 5.5. It is also true for the case of shored construction as shown in Fig. 5.8. Failure is obtained by extensive yielding of the reinforcing steel, at the connection, and its ultimate load capacity is well above that of a non-continuous beam.

The horizontal reactions supported by the hinges for the situation of full span loading in Case 1 are well above those for the remaining cases, as shown in Fig. 5.6, but comparable to the other cases for one span loading. However the reactions are coupled over one single support, thus allowing for the use of some local resisting device. For the beams in Cases 2 and 3, even though the reactions are of smaller magnitude they must be supported by the end abutments or by a single intermediate hinge.

From the observations made to this point, it is concluded that:

a) Cases 4 and 5 appear to be a good alternative for the case of non continuity. Their service load range behavior is better, as far as deflections are concerned and, more importantly, they do eliminate the undesireble joint. No horizontal reactions are created at the supports. After yielding of the deck connection reinforcement steel, the beams will behave as if a joint were provided at that location, thus gaining all the ductility capacity provided by the non-continuous beams.

b) If hinges are used they should be placed in pairs over the intermediate supports as in Case 1. The behavior of the beams is enhanced remarkably in deflections, strength and ductility. It constitutes a valid, more economical alternative for a fully continuous structure.

5.2.2 Deck-Continuity Over Hinged Supports

Among the different beams analyzed priviously the beam supported as in Case 1, with deck-continuity over hinged supports, presented an interesting behavior. Its response under uniformly distributed load is the closest to the response of a fully-continuous beam under the same loading conditions. Further analyses are made to compare the responses of both FCB and FCD under this and other situations of loading. Some conclusions are described next.

(a) Linear Response

From Figs. 5.7 and 5.8 it is observed that both beams present a very similar stiffness within service load range. Linearity extends up to a load level approximately eight times the total dead load, for either shored or unshored construction.

(b) First Cracking

First cracking of the deck slab occurs at a load level about four times the total dead load. Cracking is first developed in a region near the internal supports, as shown by point 2 in Fig. 5.7. Cracking of the

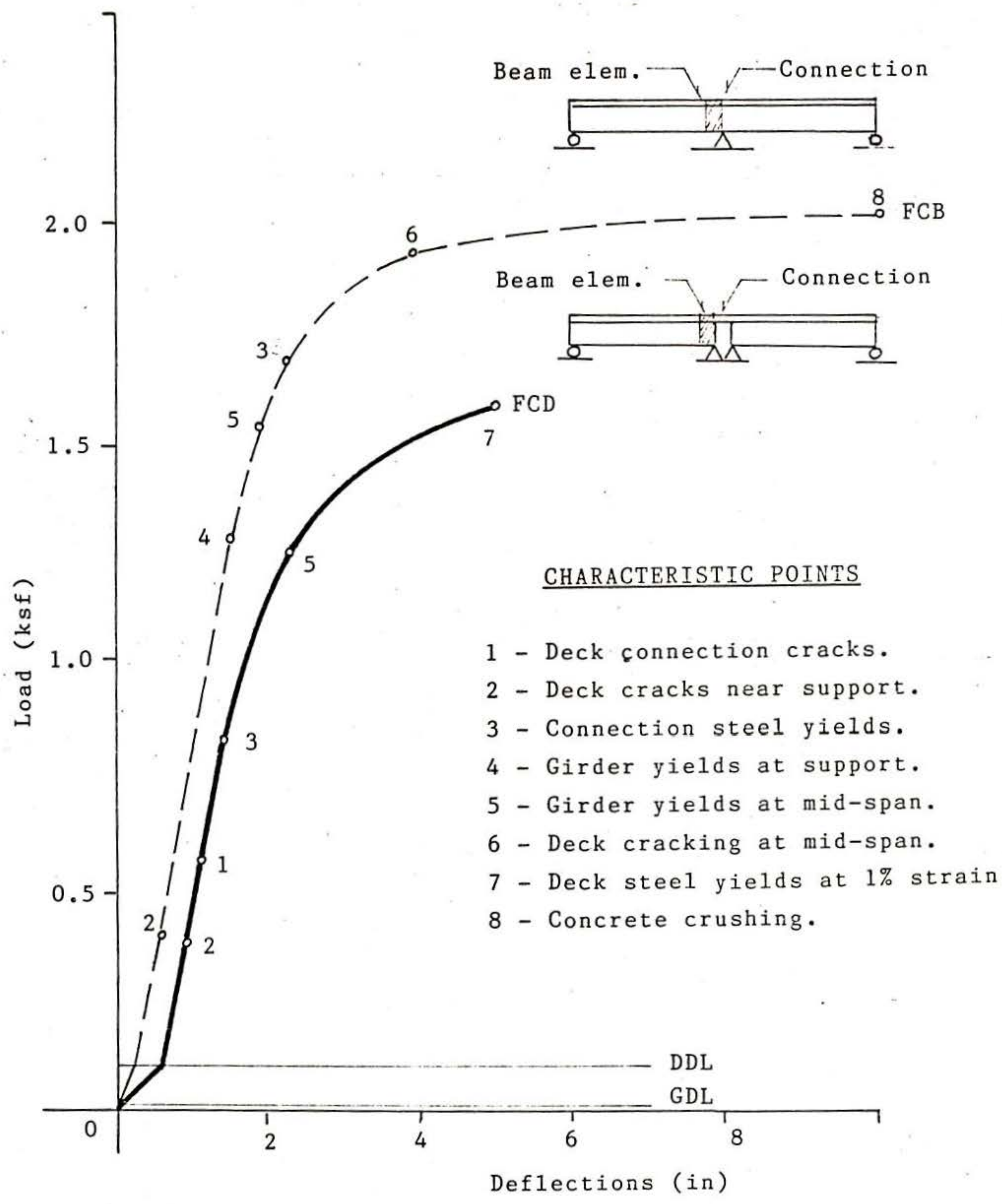


Fig 5.7 - Load-deflection responses for the FCB and FCD beams, both under unshored deck construction and loaded at both spans.

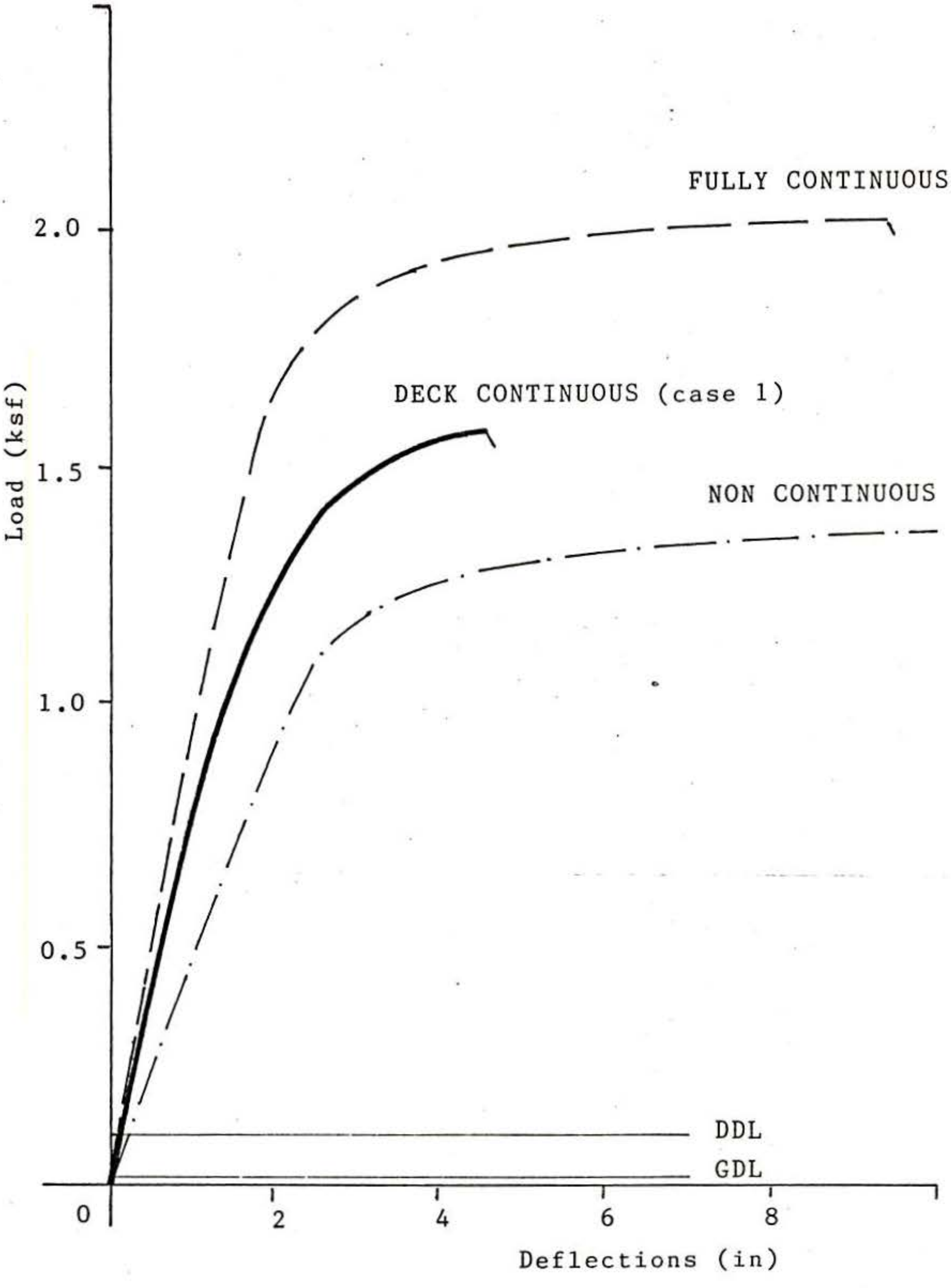


Fig 5.8 - Load-deflection responses for beams under full span loading and with shored deck construction.

deck connection in the FCD beam follows closely, at five times the total dead load (point 1).

(c) Yielding of the Deck Reinforcement

Yielding of the deck reinforcement in the FCD beam (point 3) occurs at a load level eight times the total dead load, when the beam response becomes nonlinear. However, in the FCB deck reinforcement yield happens at a much higher load, after yielding of the steel girders (points 4 and 5).

Force build-up in the deck connection of the FCD beam is virtually linear before yielding of the reinforcement. After that a constant force is maintained until failure, see Fig. 5.9. The development of stresses in the deck reinforcing steel of both beams is shown in Fig. 5.10. It can be observed that under service load conditions, when cracks are expected to be controlled, steel stresses remain in the elastic range therefore allowing cracks to close under unloading of the structure.

(d) Load Capacity

Failure of the FCD beam occurs by extensive yielding of the deck reinforcement whereas in the FCB crushing of the deck concrete is observed after a considerable mid-span deflection, and at a higher load as shown in Fig. 5.7. However, the load capacity of a deck-continuous beam may be enhanced by increasing the amount of deck reinforcement at the connection. Fig. 5.11 shows a comparison of their responses for different reinforcement ratios of 1.5, 2.0, 2.5 and 3.0 percent respectively. The same amount of deck reinforcement is maintained for

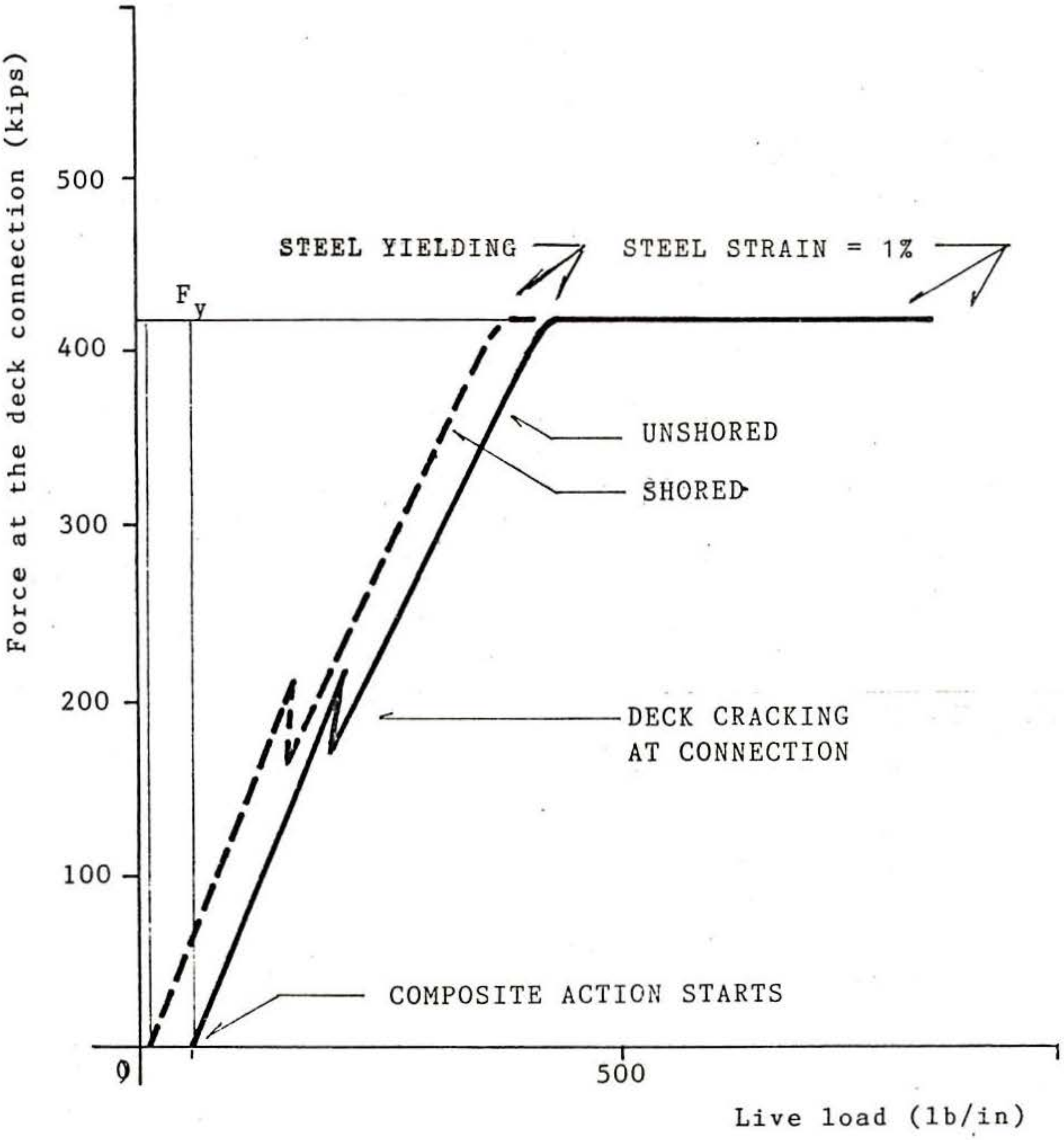


Fig 5.9 - Force build-up at the deck connection. Beam case 1: Full span loading, shored and unshored deck construction.

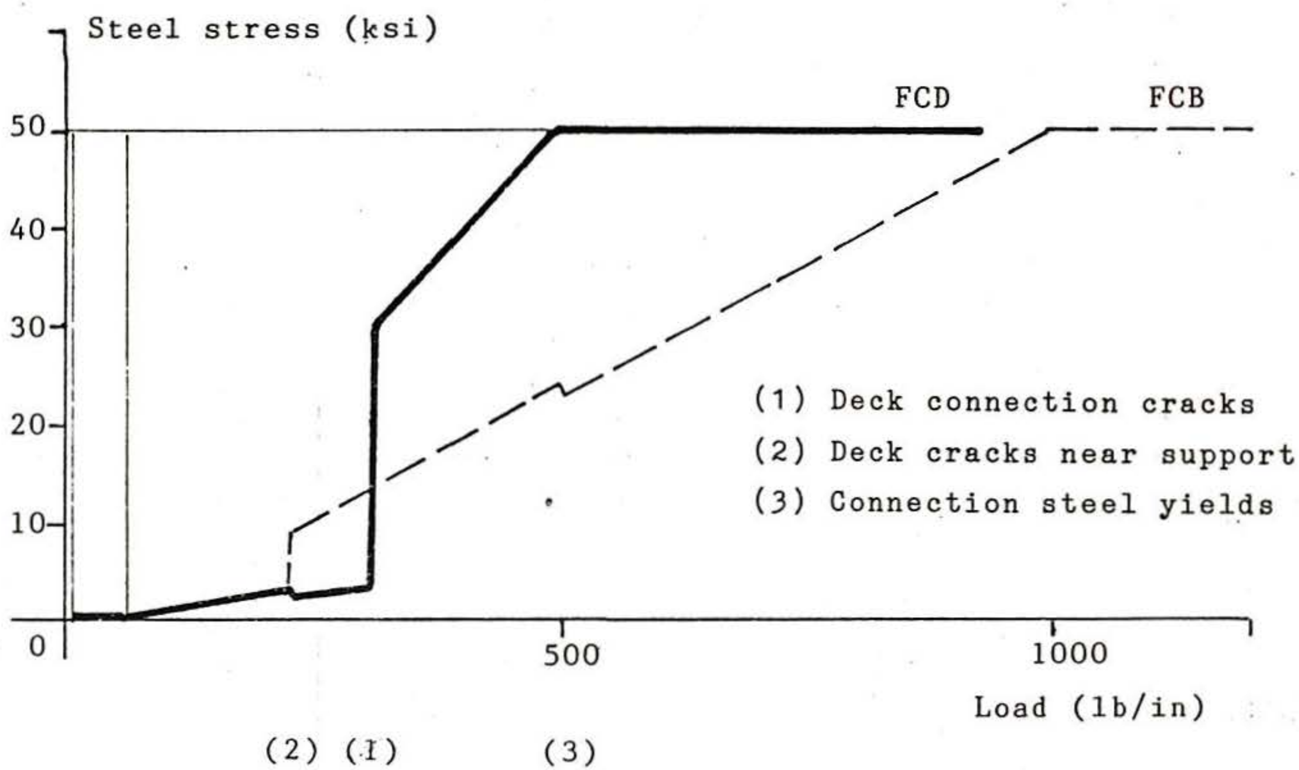


Fig 5.10 - Stresses in the deck reinforcing steel for full span loading and unshored construction. Refer to Fig. 5.7.

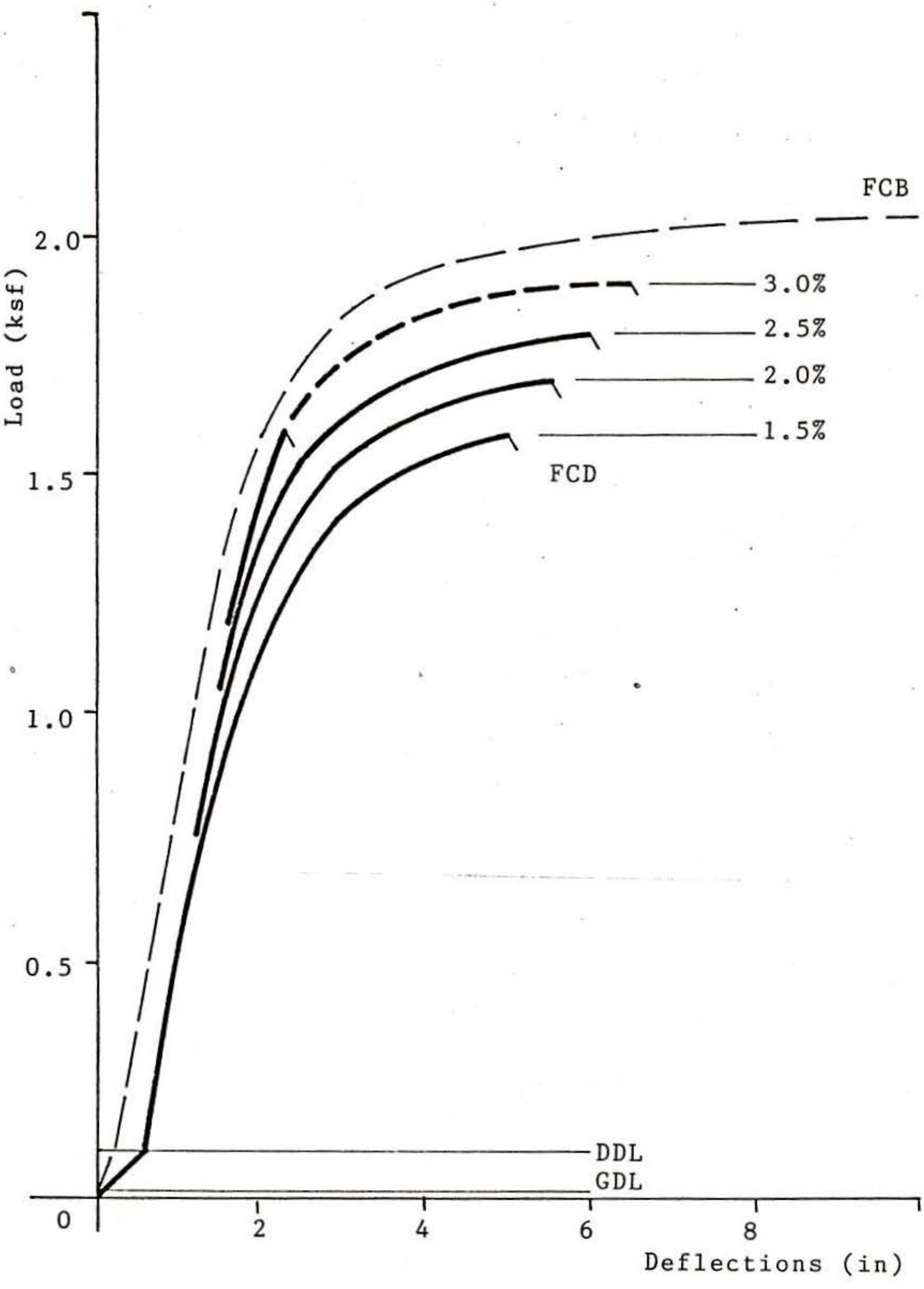


Fig 5.11 - Load-deflection responses for continuous deck beams, Case 1, with different reinforcement ratios at the connection. Unshored construction and full span loading.

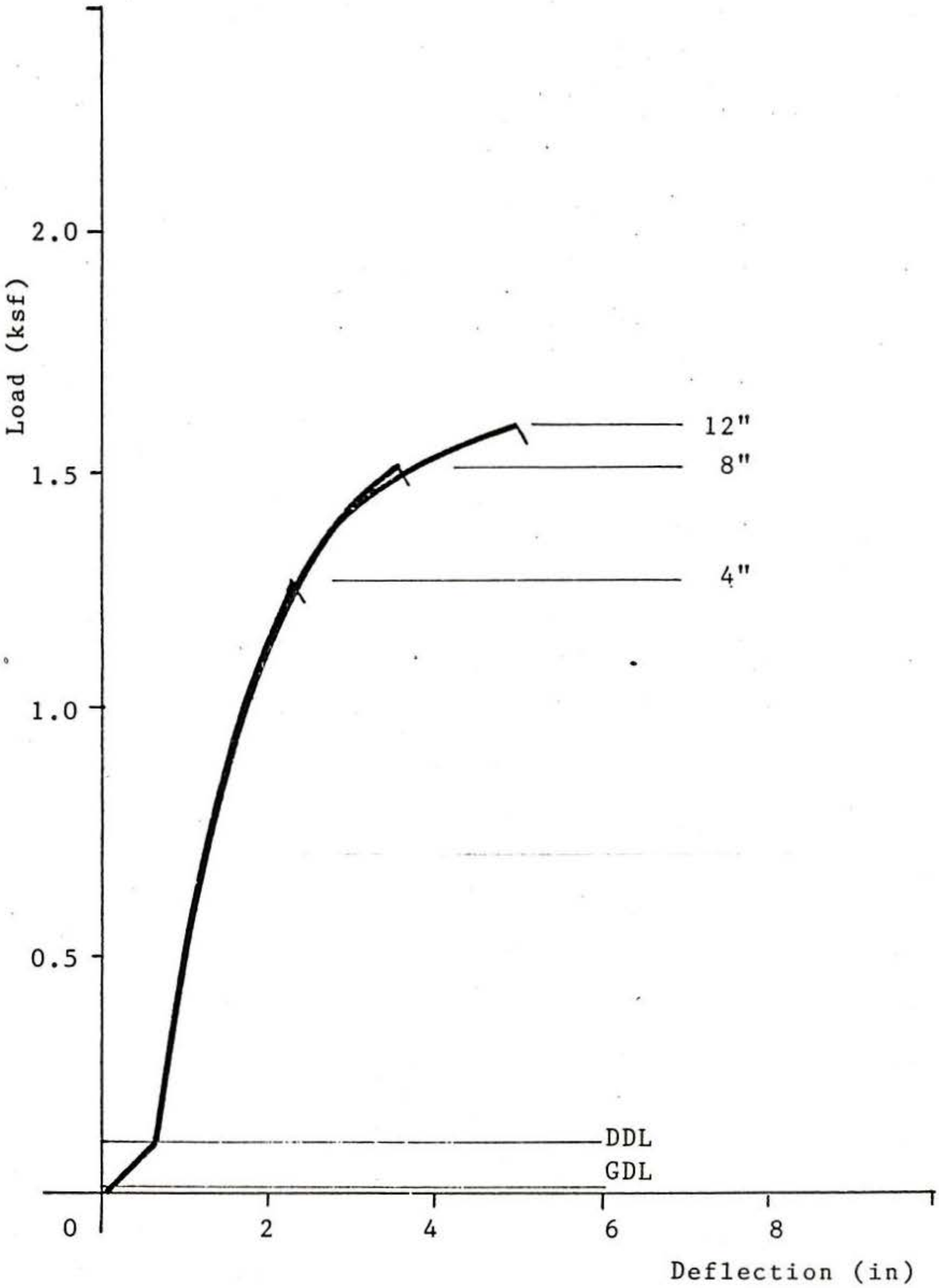


Fig 5.12 - Responses of a deck-continuous beam with different widths of the deck connection. Unshored deck construction and full span loading.

the spans. It is observed that the beam response comes closer and closer to the response of the FCB. But for reinforcement ratios of 3.0 percent and more the deck becomes over-reinforced causing failure to occur by crushing of concrete with much less ductility.

(e) Ductility Capacity

Ductility and strength of a FCD beam are associated with the width of the concrete deck connection. The shorter is the gap between adjacent girders the higher is the strain associated with the same amount of rotation of the end faces of the girders, thus allowing failure to occur prematurely. However, their responses under service loads are not differentiated by this variable, as shown in Fig. 5.12.

A wider deck connection could be achieved by separating the end faces of the adjacent girders, but a more robust support would be required. Yet, another solution could be to provide some small region near the gap to be unbonded, i.e. the deck-girder interface at both sides of the end faces of the girders could be left unbonded when casting the deck slab. The analytical model developed herein is not able to handle such a situation. However, should the unbonded length be kept small it is expected that the results of this analysis may be adequate.

(f) Sustained Loading

The development of mid-span deflections over a period of two years under a sustained live load is shown in Fig. 5.13. During this period, shrinkage and creep of the deck concrete are expected to cause the initial deflections to increase. It is once more observed that a FCD beam behaves similarly to a FCB, unlike the non-continuous one. A non-continuous beam has a 70 percent increase in deflection whereas the other two beams present an initial increment of about 50 percent, in a six months period, decreasing to a steady 30 percent after two years. It is worth noting that such responses correspond to a post-cracking behavior of the decks, as seen in Fig. 5.7.

(g) Temperature Effect

Under the action of the same service live load the beams are also analyzed for the effects of two temperature variation gradients. A constant temperature variation through the cross-seccions is assumed to model a seasonal temperature change. For a daily oscillation of temperature a linearly decreasing gradient is used, as seen in Fig. 5.14. No significant changes in deflections nor in cracking development are noted for any of the beams analyzed.

(h) Compressive Effect

An amazingly similar response is presented by the three beams when all supports are hinged, i.e. when no horizontal movement is permitted after dead load is applied. In this situation horizontal reactions are created at the hinges. The compressive effect provided by these reactions overwhelmingly dictates a tremendously stiff response of the beams. Their load capacity are nearly doubled and their load-deflection responses become bearly distinguishable, as shown in Fig. 5.15.

In this situation it is undoubtly clear the superiority of a FCD beam over the other two beams. Such constructional scheme will avoid the use of expansion joints and yet permit the use of precast elements

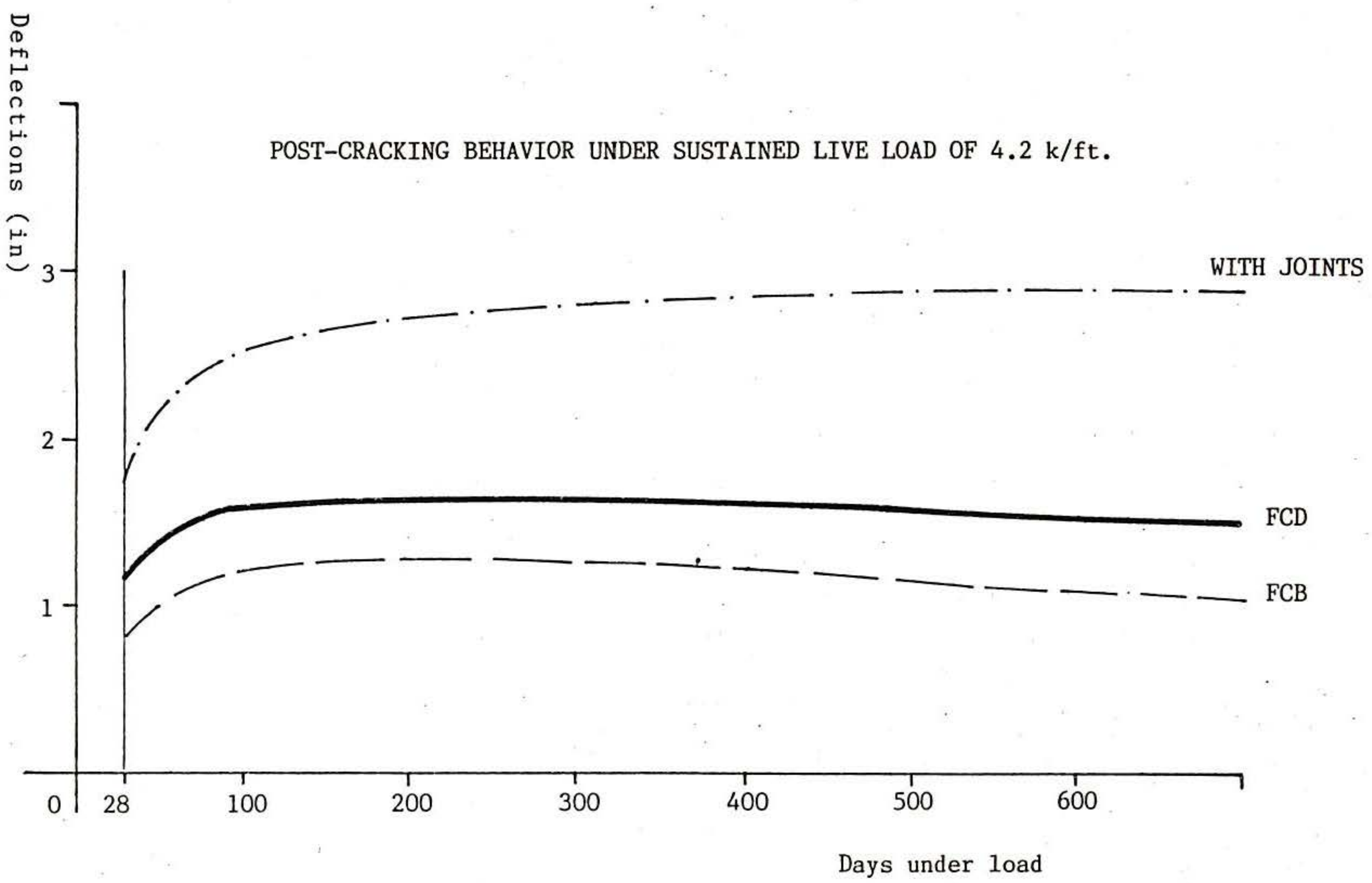


Fig 5.13 - Development of mid-span deflections with time.
(Refer to Fig 5.4)

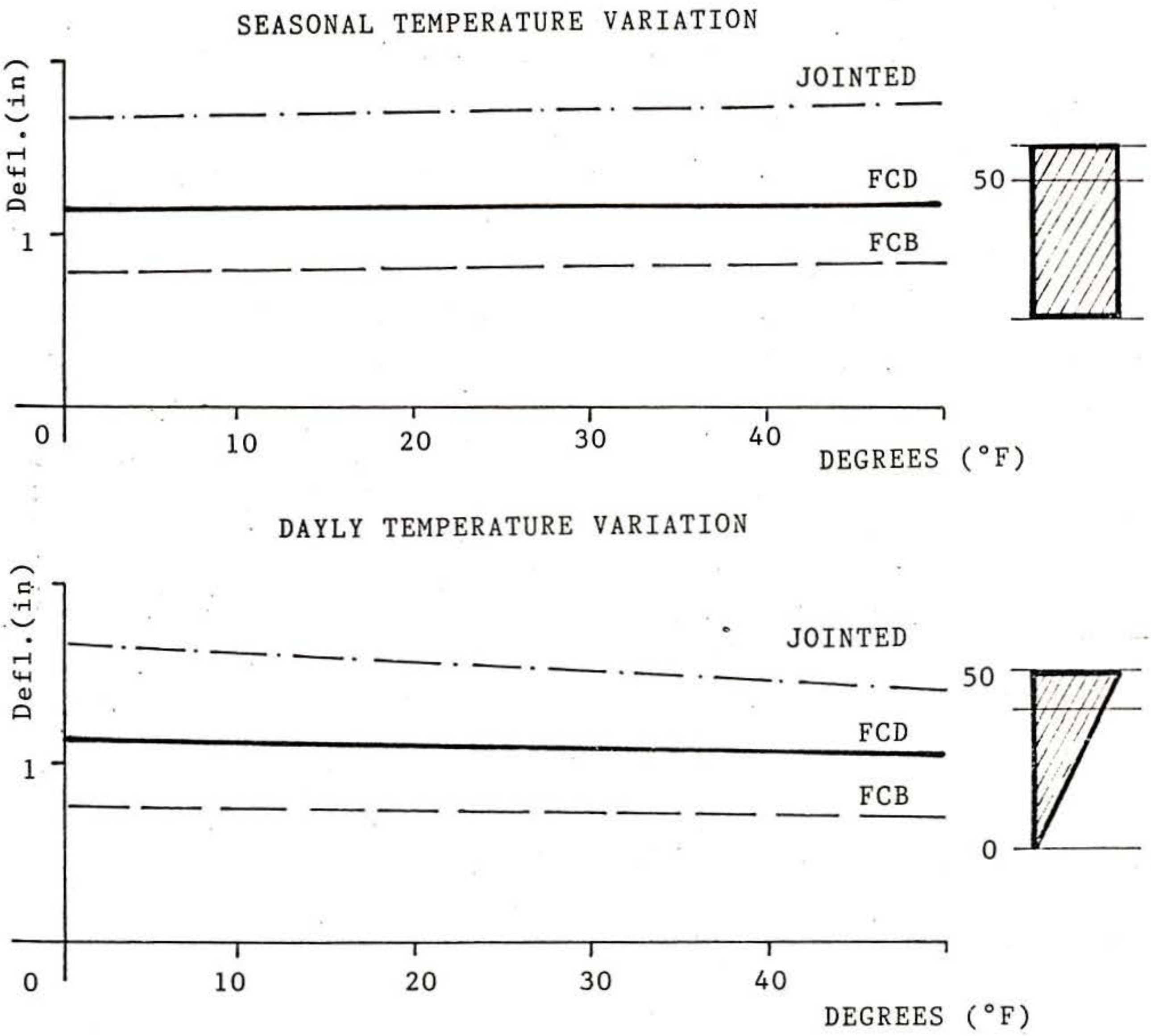


Fig 5.14 - Development of mid-span deflections for temperature variation. (Refer to Fig 5.4)

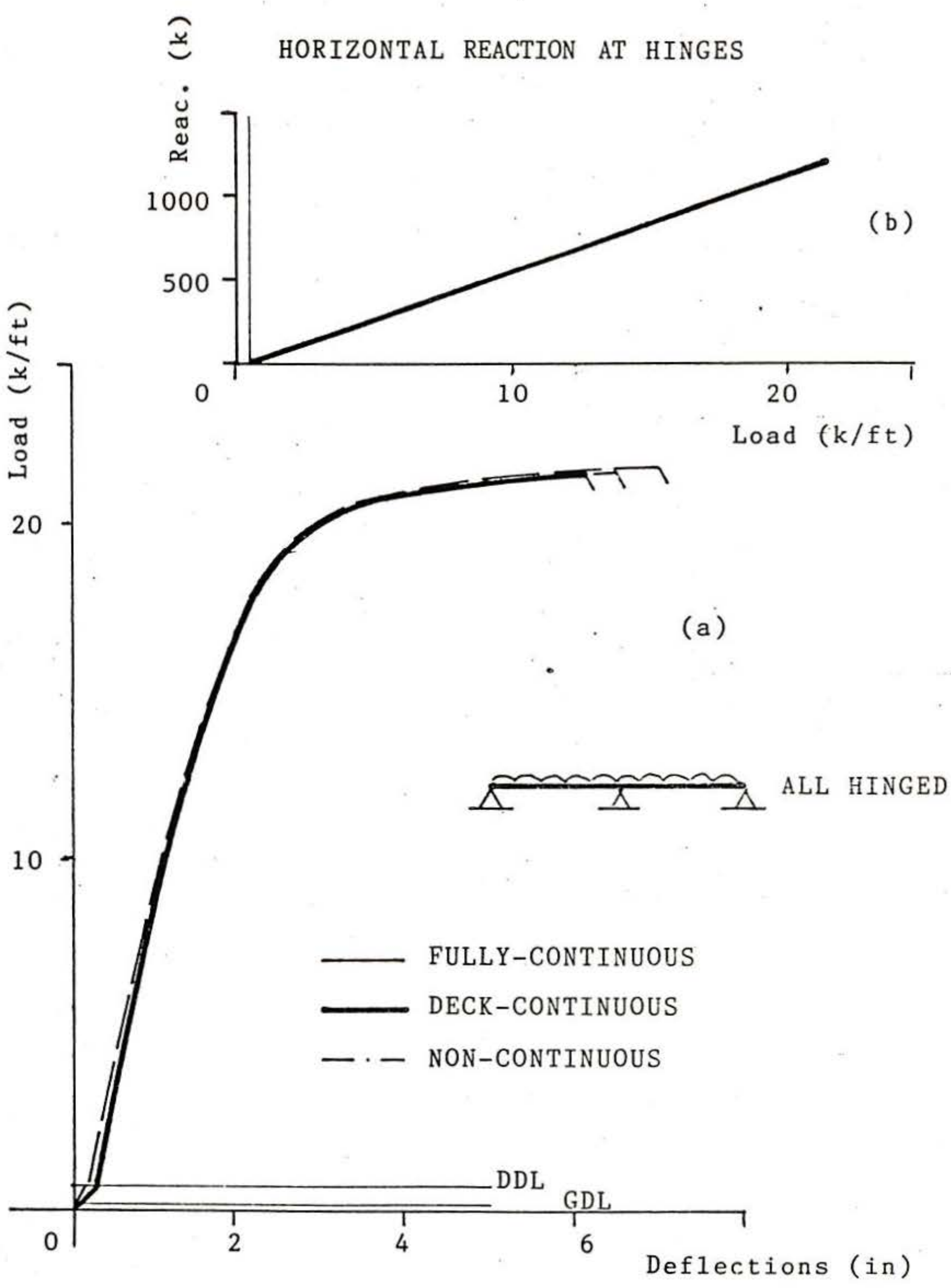


Fig 5.15 - Load-deflection response for beams loaded on full span and hinged at all supports (a). Horizontal reactions at the exterior hinges (b).

therefore lowering the cost associated with construction and maintenance.

The results presented up to this point predict the behavior of a particular two-span beam composed of steel girders and a reinforced concrete deck slab. A good performance is observed by the deck-continuous beam as compared to the upper and lower bound cases of full and no continuity. It is expected that similar conclusions may be extended to beams with more than two spans.

5.3 Analysis of a Jointless-Deck on Four-Span Beam With Precast Prestressed Concrete Girders.

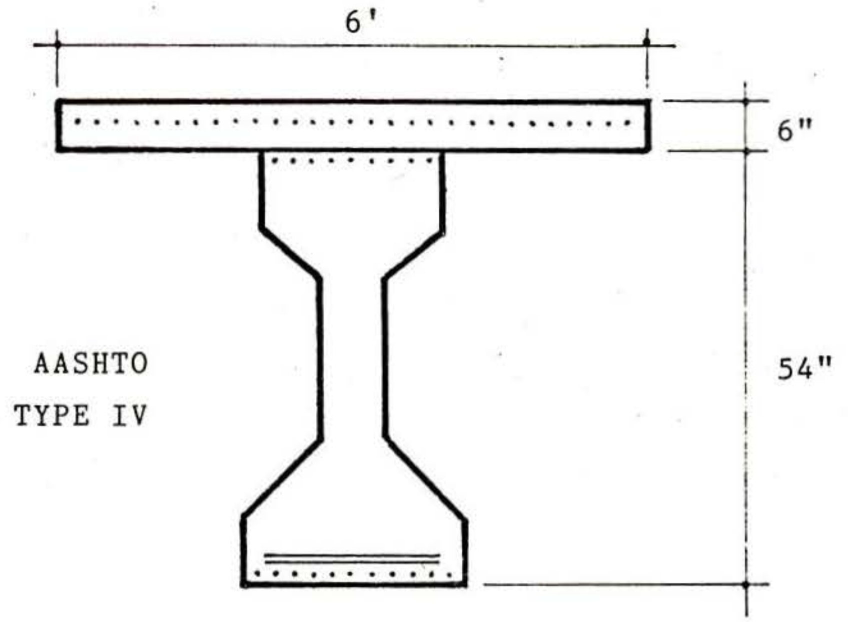
5.3.1 Properties

A four-span bridge beam, composed of four pre-tensioned concrete girders and a 6 ft by 6 in reinforced concrete deck slab, is analyzed to study the performance of a joint-free fully-continuous deck system. Comparison is made to beams with no continuity and full continuity for live load only. Layout, cross-sections and material properties are shown in Figs. 5.16, 5.17 and 5.18. Two situations are considered:

(a) The beams have four equal spans, each with a 66 ft precast pre-tensioned AASHTO TYPE IV girder.

(b) The beams have four unequal spans, with two exterior spans of a 24 ft precast pre-tensioned AASHTO TYPE II girder and two interior spans being the same as in case (a).

All girders are pre-tensioned by straight 7-wire strands 270 K grade



CROSS-SECTION AT FOUR SPANS

Girders

$A_c = 789\ in^2$
$I_c = 260741\ in^4$
$W_t = 822\ plf$
$E_c = 4.5\ 10^6\ psi$
$f'_c = 6000\ psi$

Deck

$A_s = 432\ in^2$
$W_t = 450\ plf$
$E_c = 3.5\ 10^6\ psi$
$f'_c = 3500\ psi$

Reinforcement

	span	supports
deck	1.5%	2.6%
girders		$A'_s = 2\ in^2$
		$A_s = 2\ in^2$

Prestressing

(32) 7 wire strands

$f_{pu} = 270\ ksi$
$f_{pi} = 0.7\ f_{pu}$
$A_{ps} = 2.72\ in^2$
$e = 21.73\ in$

Fig 5.16 - Cross-section and material properties for the beam with four equal spans.

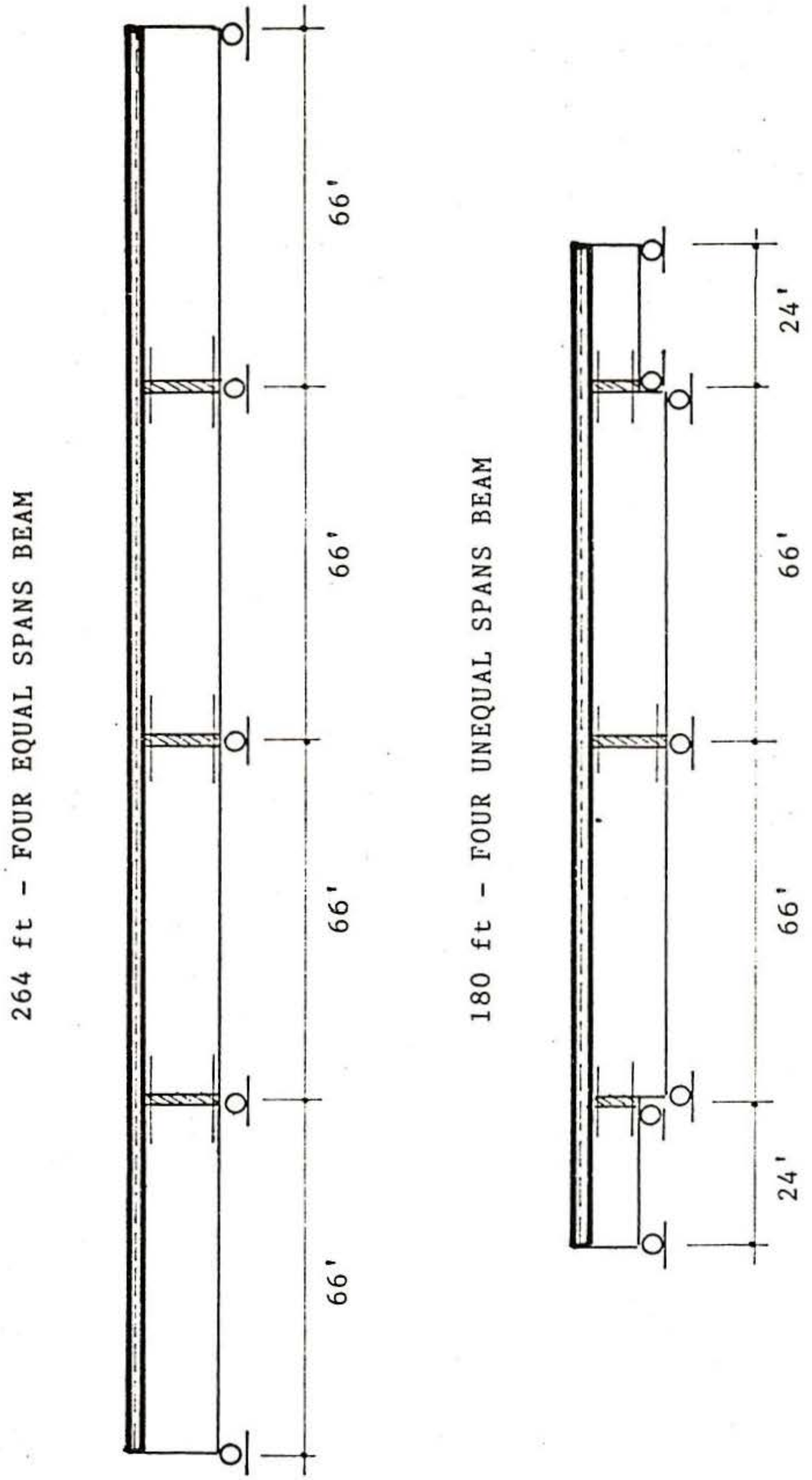
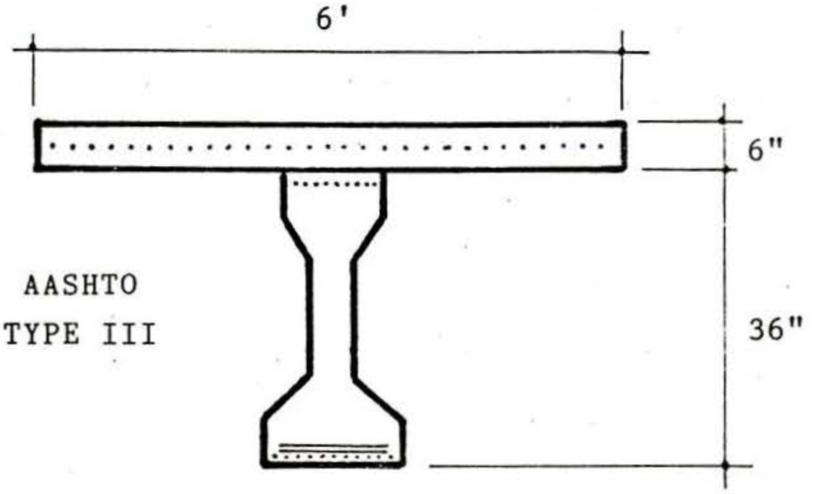


Fig 5.17 - Layout and reinforcement arrangement for both prestressed concrete composite beams.



CROSS-SECTION AT SHORTER SPANS

$A_g = 369\ in^2$
$I_g = 50797\ in^4$
$W_t = 384$ plf

<u>Reinforcement</u>			<u>Prestressing</u>
	spans	supports	(14) 7 wire strands
			$f_{pu} = 270$ ksi
deck	1.5%	2.6%	$f_{pi} = 0.7\ f_{pu}$
girders		$A_s' = 1.2\ in^2$	$A_{ps} = 1.19\ in^2$
		$A_s = 1.2\ in^2$	$e = 12$ in

Fig 5.18 - Cross-section and material properties for the two shorter spans.

low-relaxation steel at an initial stress fi = 0.7 fpu. Prestressing is designed for zero stress at top girders under dead load. Reinforcement of 1.5% is also provided in the deck for the entire span. Additional deck reinforcement of 1.1% is also provided over the intermediate support. For the beams with full continuity for live load additional girder reinforcement is provided for negative and positive moments at the supports and the gap between adjacent girders is filled with concrete to assure perfect girder continuity. Unshored construction is assumed and bearing pads are provided for all supports. If hinges are used, they are effective only after dead load is applied.

5.3.2 Modeling

The analysis is performed by modeling the beams by 12 and 11 elements for the short and long spans respectively. All elements are subdivided into 20 layers for the girders and 10 for the deck. For the deck-continuous beams three connection elements are provided, one at the junction of each two adjacent girders. Prestressing and dead loads are applied by using the Load Increment Method and the Displacement Increment Method is used for applying live load up to failure. Various situations of loading, supports, temperature and time effects are studied and the results lead the observations that follow.

5.3.3 Results

(a) Equal Spans and Loading

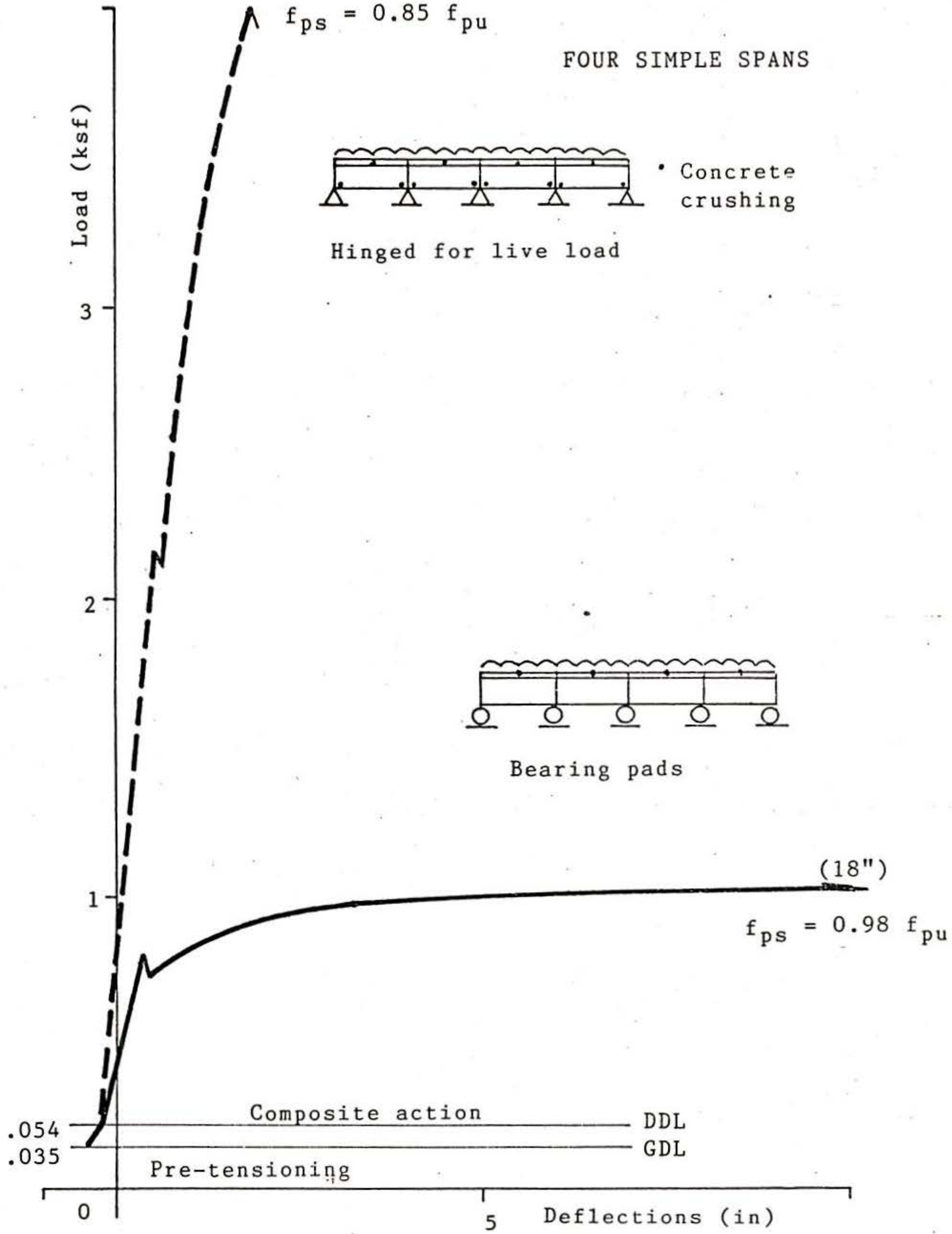


Fig 5.19 - Load-deflection responses under full span loading.

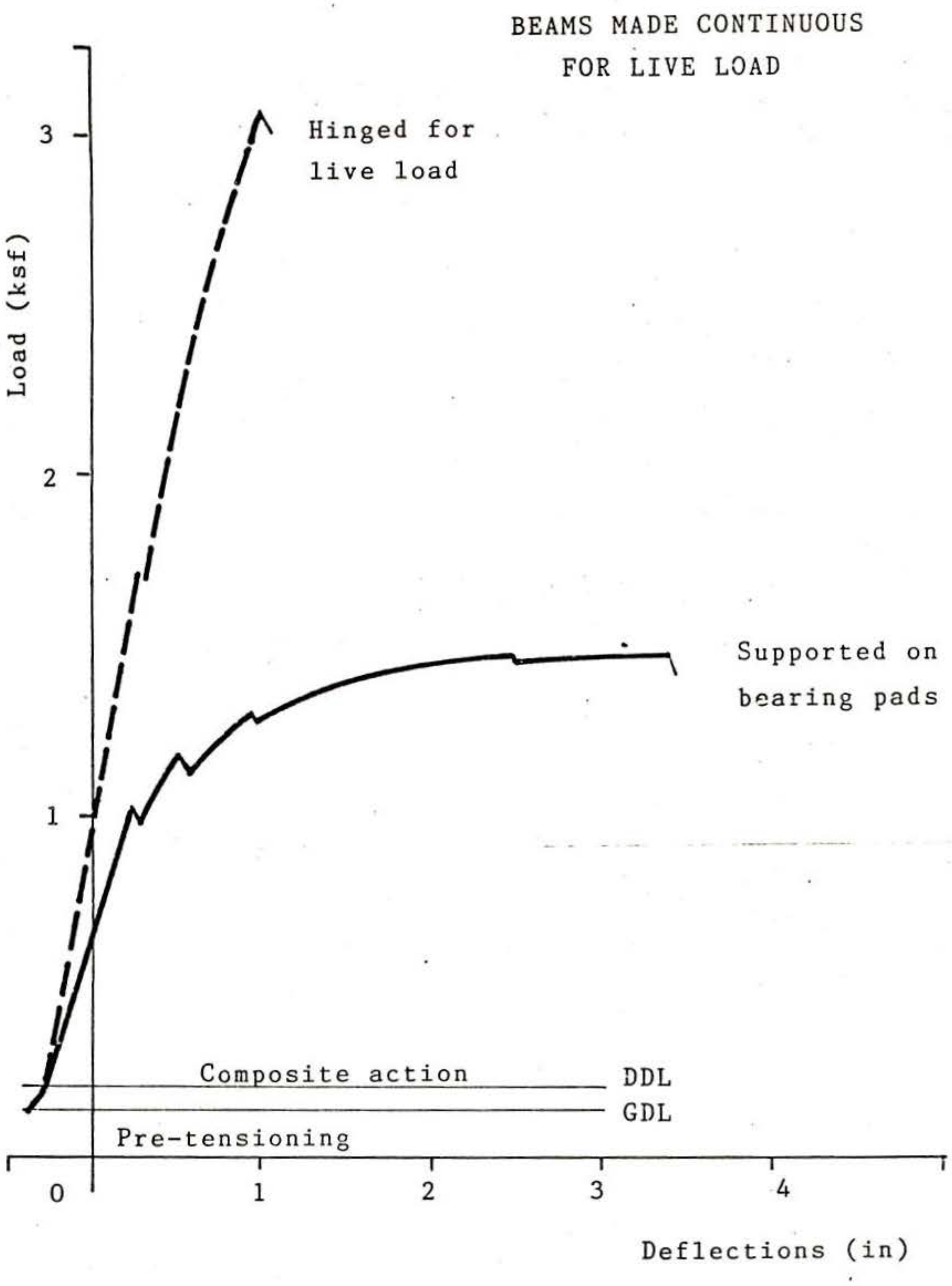


Fig 5.20 - Load-deflection responses under full span loading for the beams made continuous for live load.

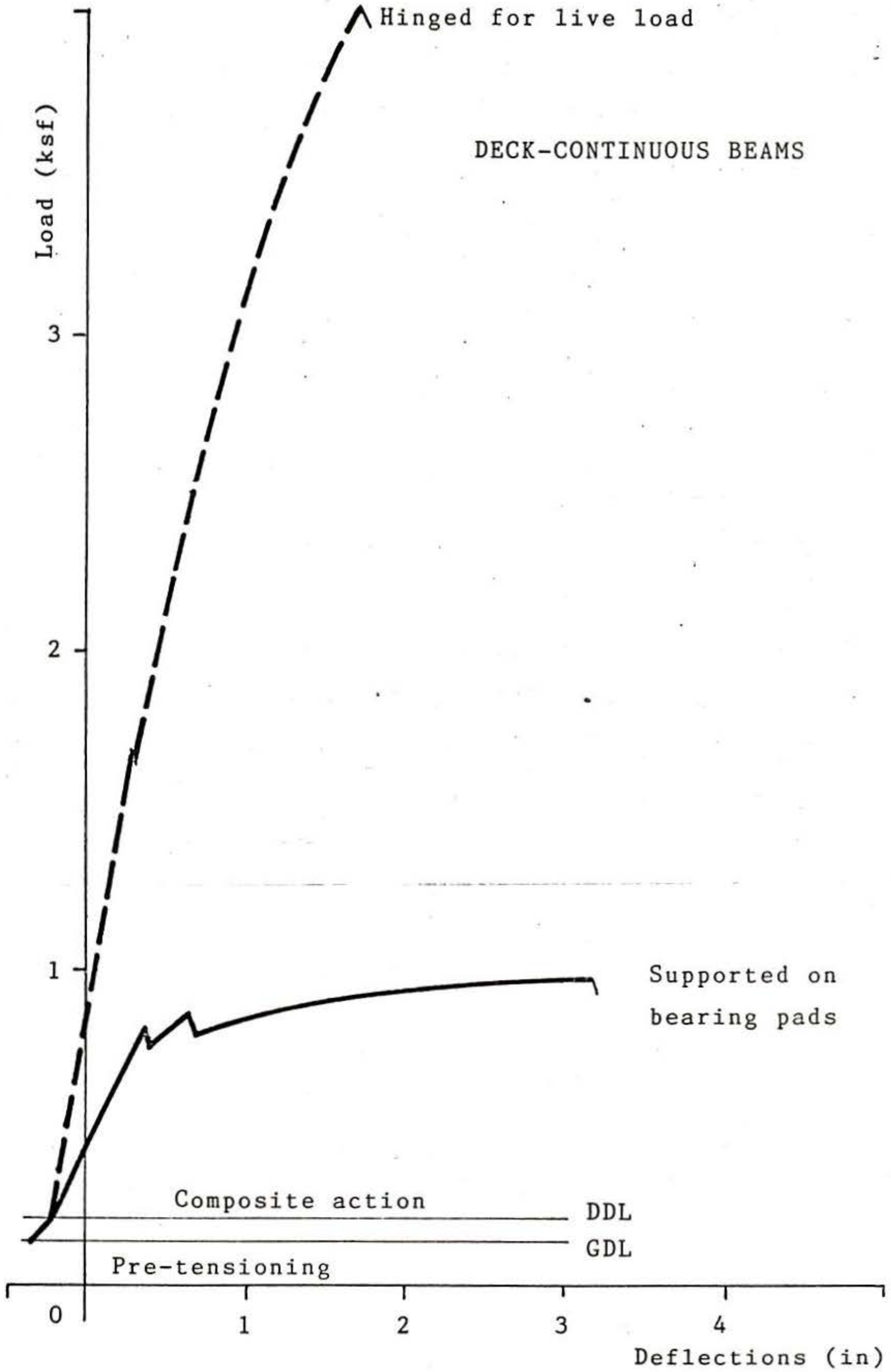


Fig 5.21 - Load-deflection responses under full span loading.

Figures 5.19, 5.20 and 5.21 show the load-deflection responses for the three cases of non continuity, full continuity for live load and deck continuity only, respectively. Beams are loaded on the entire span and two situations of supports are considered: bearing pads and hinges for live load. Deflections are measured at center of the exterior spans for all beams.

When supported by bearing pads, the beams show a rather ductile behavior, especially for the non-continuous cases failing by crushing of concrete at mid-span. Their stiffnesses are greatly increased when hinges are considered but failure is sudden, by concrete crushing at the hinges with no ductility plateau whatsoever.

(b) Equal Spans and Unequal Loading

Comparison is shown for the three continuity cases, in Figs. 5.22, 5.23 and 5.24, where beams are supported by bearing pads and loaded at different spans: fully-loaded, exterior and interior, respectively. The most critical loading condition appears to be the case where all spans are fully loaded. Other conditions of loading, not shown, seem to have less effect in deflections. The same applies to the hinged beams shown in Figs. 5.25, 5.26 and 5.27.

From the observed results conclusions that can be drawn are not much different from the ones outlined in Section 5.2 for steel girders. The deck-continuous beam behaves quite similarly to a non-continuous beam, even though slightly improved when supported by bearing pads. When hinges are used, its behavior becomes comparable to the behavior of a fully-continuous beam.

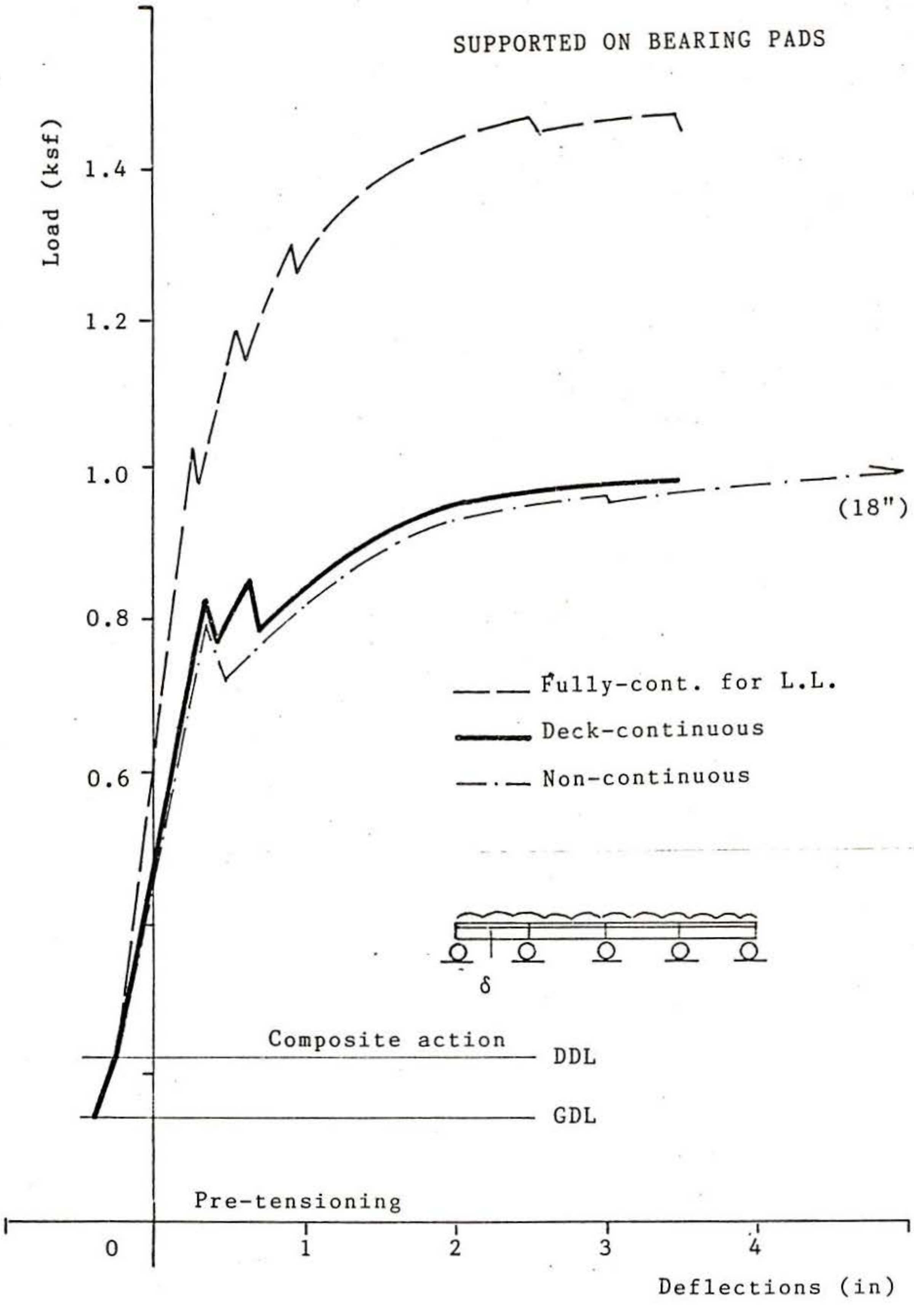


Fig 5.22 - Load-deflection responses under full span loading.

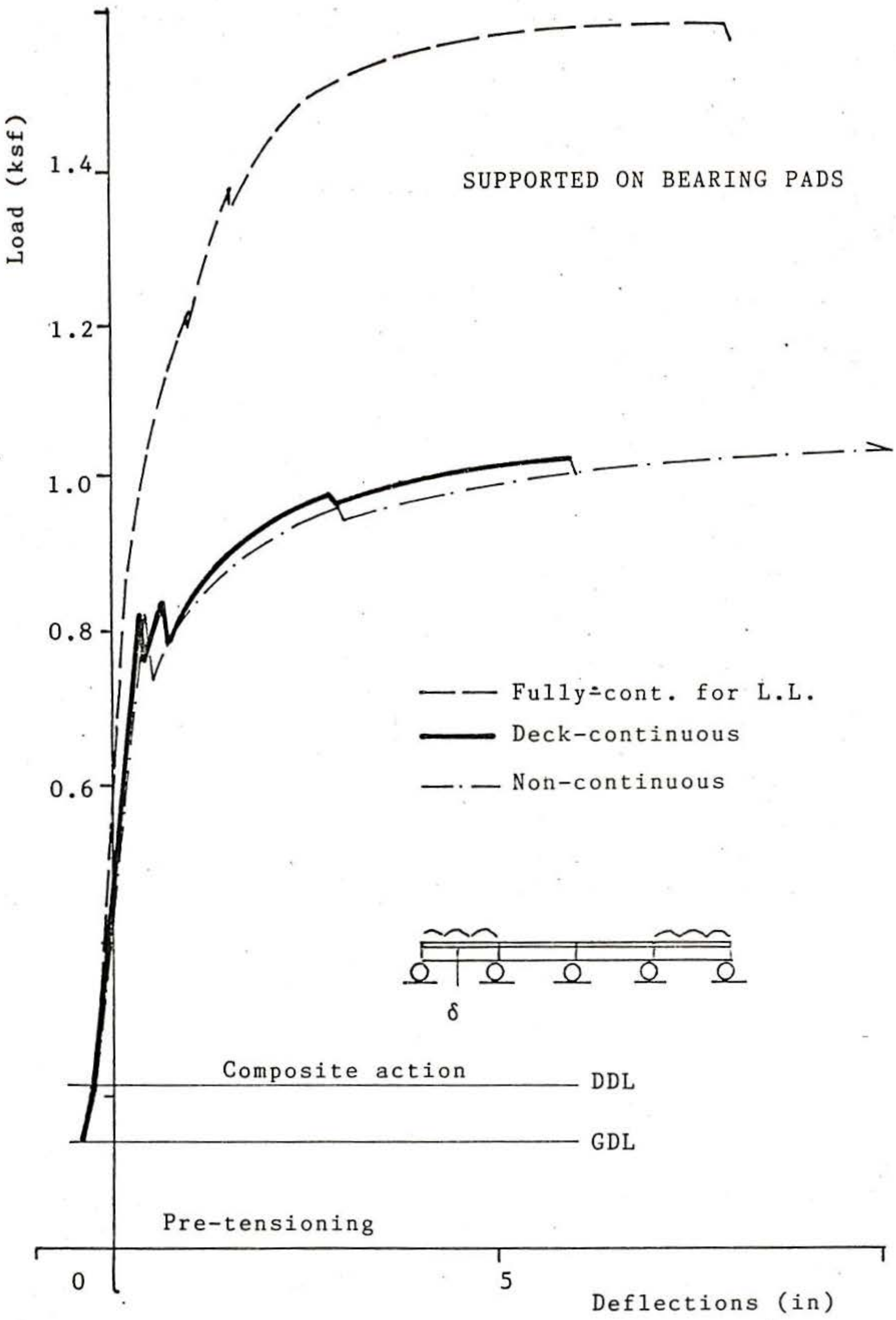


Fig 5.23 - Load-deflection responses for exterior spans loading.

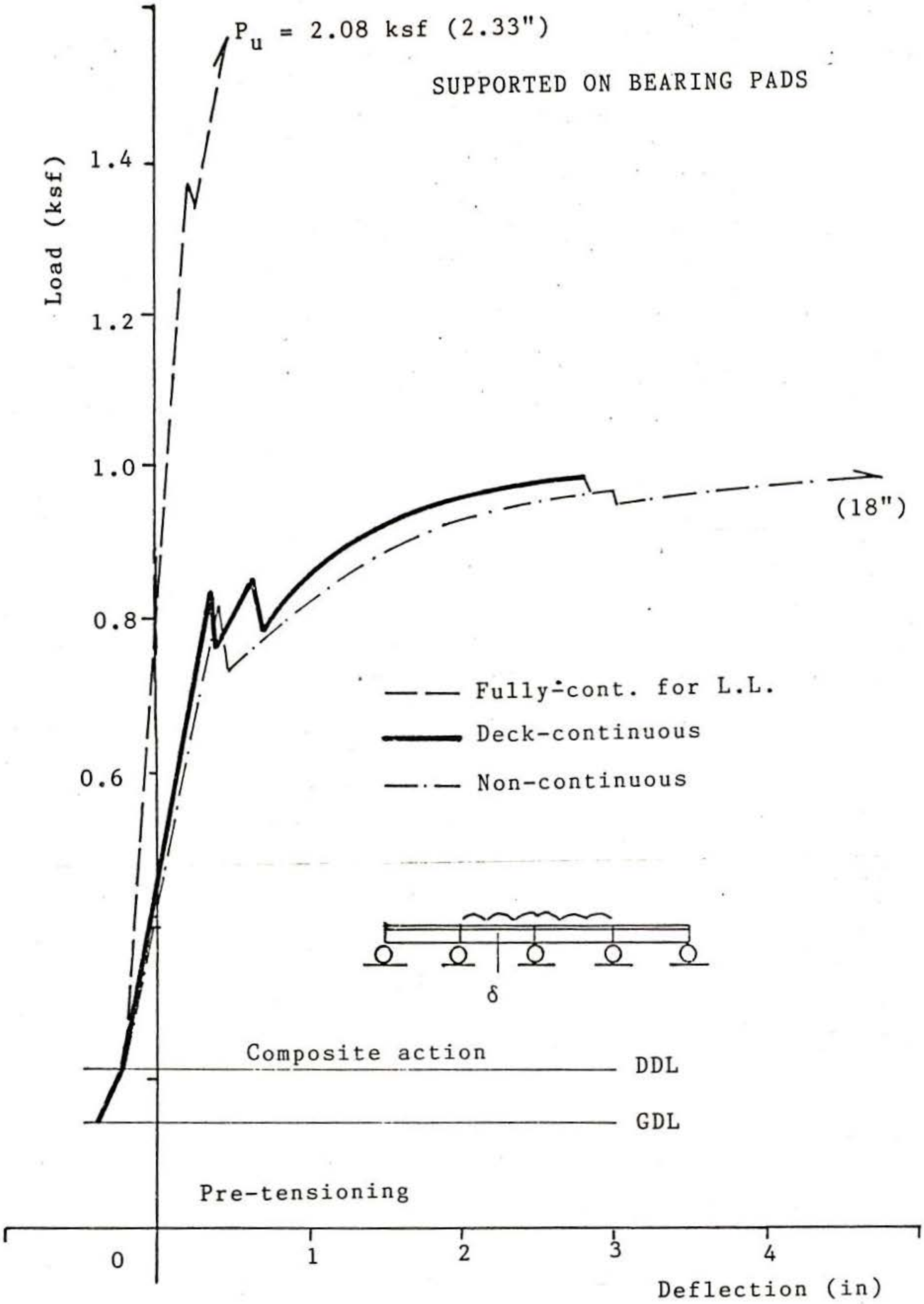


Fig 5.24 - Load-deflection responses for interior spans loading.

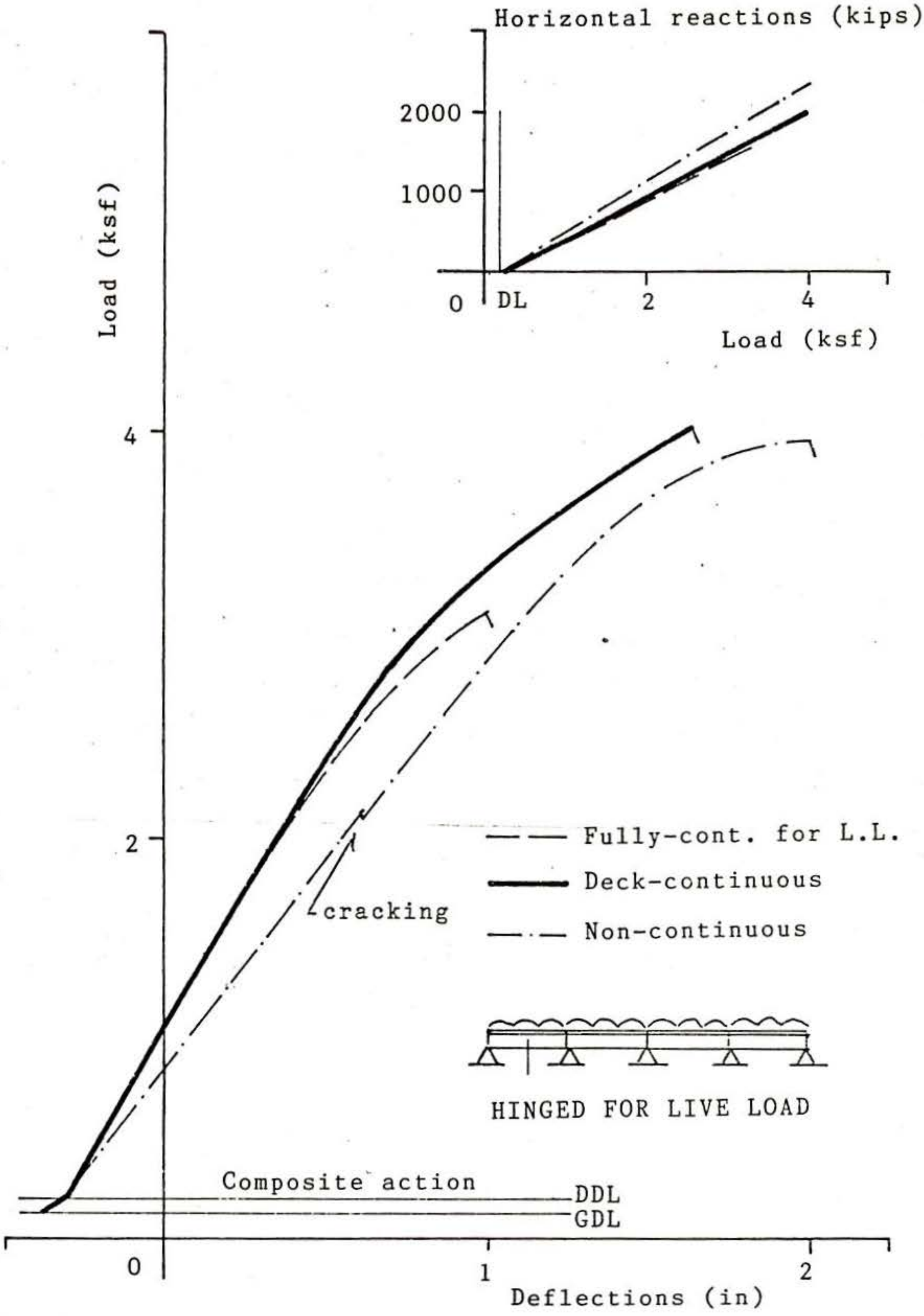


Fig 5.25 - Load-deflection responses under full span loading.

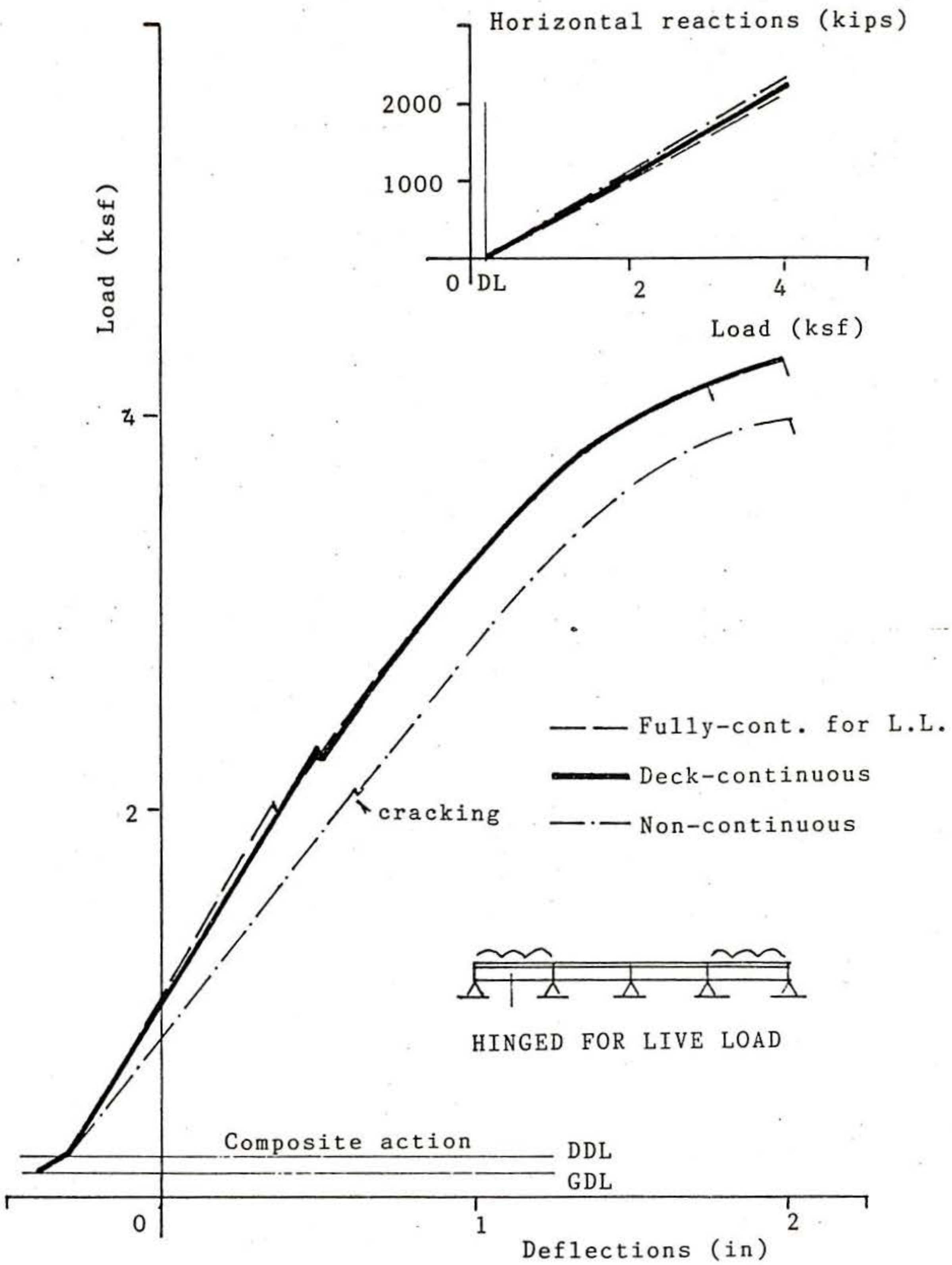


Fig 5.26 - Load-deflection responses for exterior spans loading.

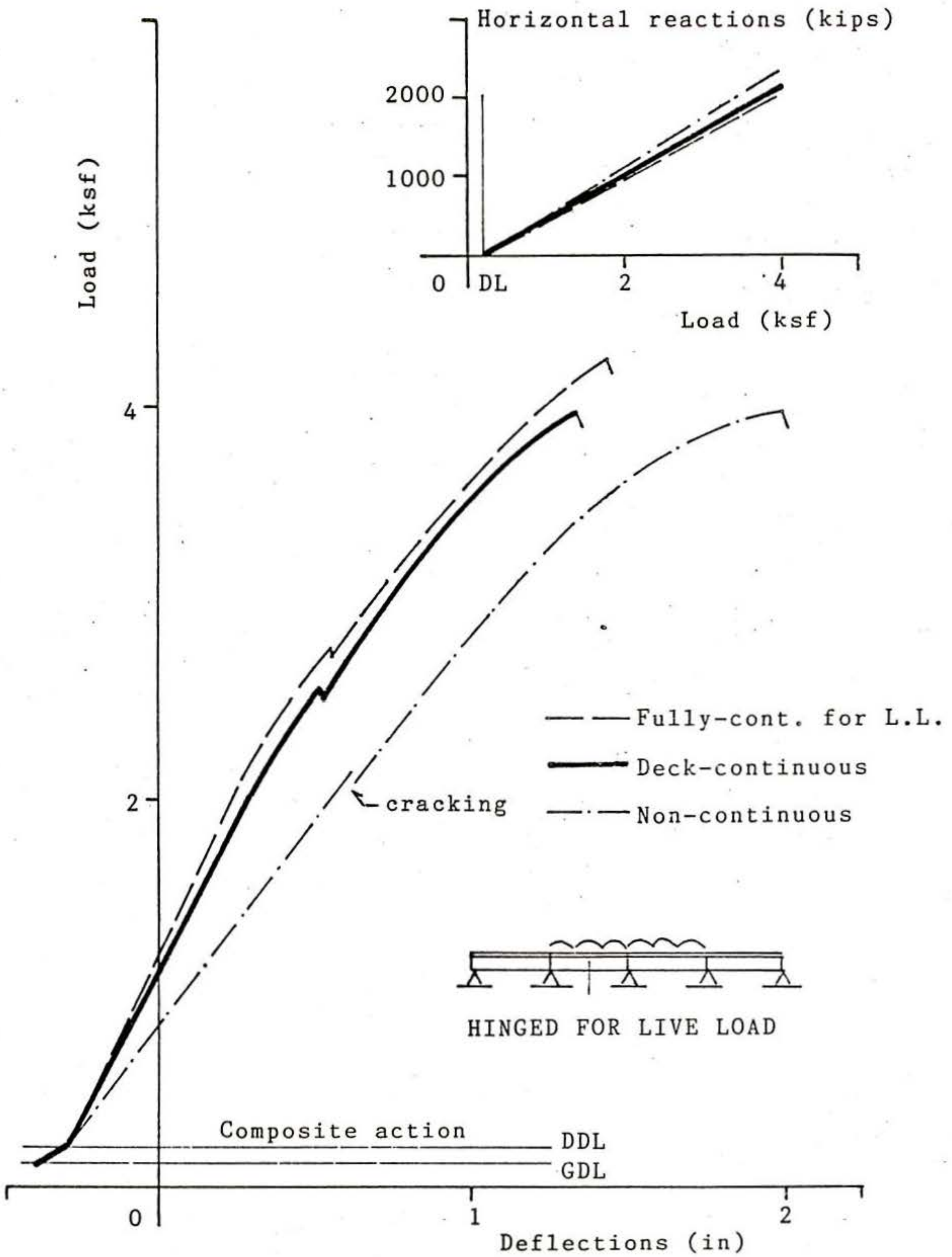


Fig 5.27 - Load-deflection responses for interior spans loading.

(c) Support Conditions

The use of hinged supports improves remarkably the stiffness and thus the response of the beams under service load conditions. However, attention shoud be paid to the very large reactions created at these hinges as shown in Figs. 5.25, 5.26 and 5.27. It may not be possible in design to accommodate such large reactions with hinges, particularly with precast concrete girders. If it is feasible to design for the large reactions developed in the hinges, the use of deck-continuous beams would be more economical than beams made continuous for live load.

On the other hand, the use of bearing pad supports is much less expensive. Deck-continuous beams with bearing pad supports present an improvement over non-continuous beams. Their responses under service loads are slightly enhanced and joints are avoided.

(d) Time and Temperature Effects

Both a deck-continuous beam and a jointed non-continuous beam are analyzed for their responses under time effects. The beams are left unloaded for a period of one year under the effects of aging, shrinkage and creep of concrete and relaxation of the prestressing steel. After one year the beams are loaded to failure. Their long-term strength is compared to the instantaneous strength when loaded at 28 days as shown in Figs. 5.28 and 5.29. No reduction in strength is found as a consequence of time effects. Both beams once more behave quite similarly.

Under the effects of a temperature gradient no perceptible difference is found in their responses as seen in Fig. 5.30. Camber is

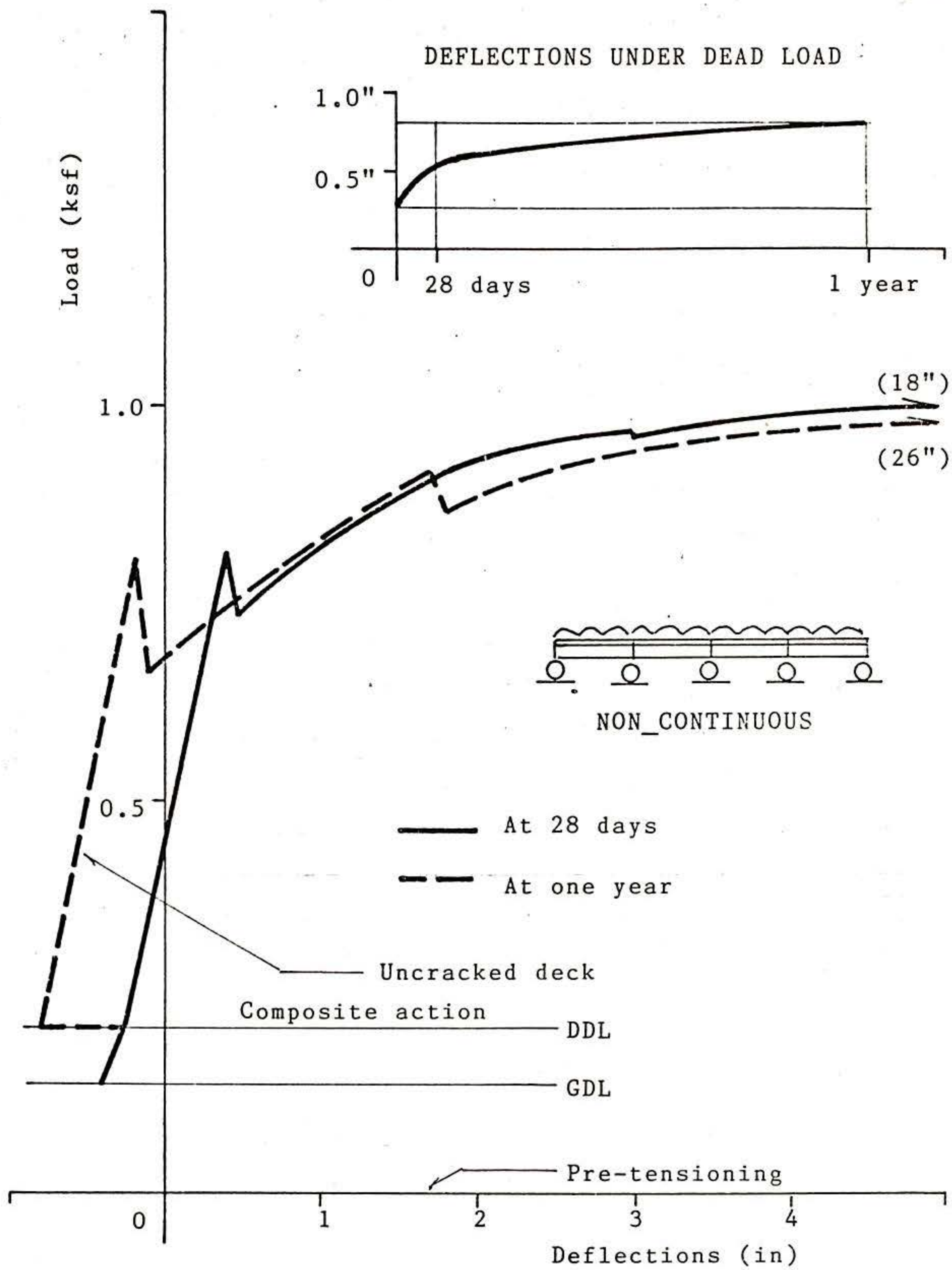


Fig 5.28 - Load-deflection responses under full span loading at ages of 28 days and one year.

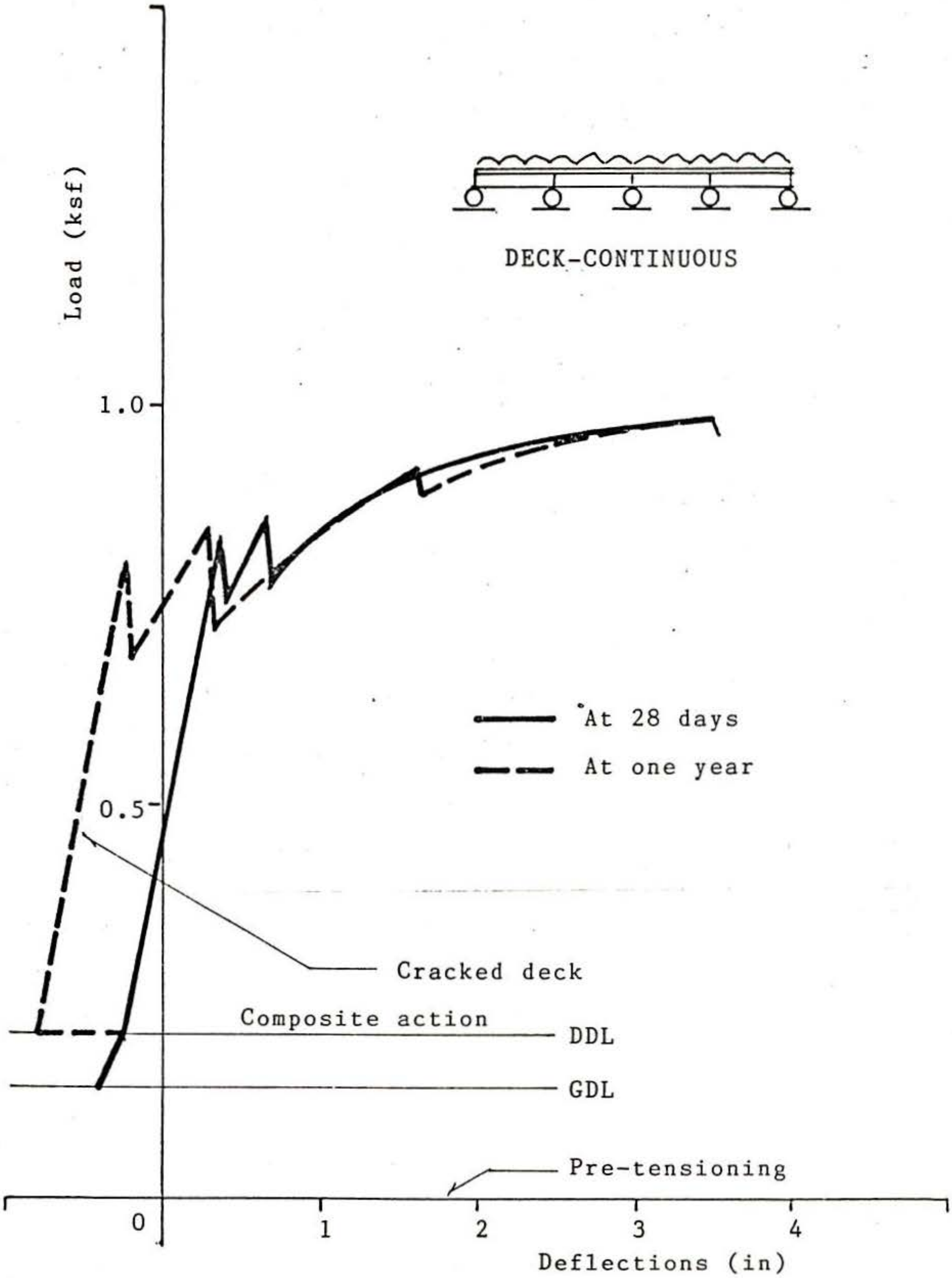


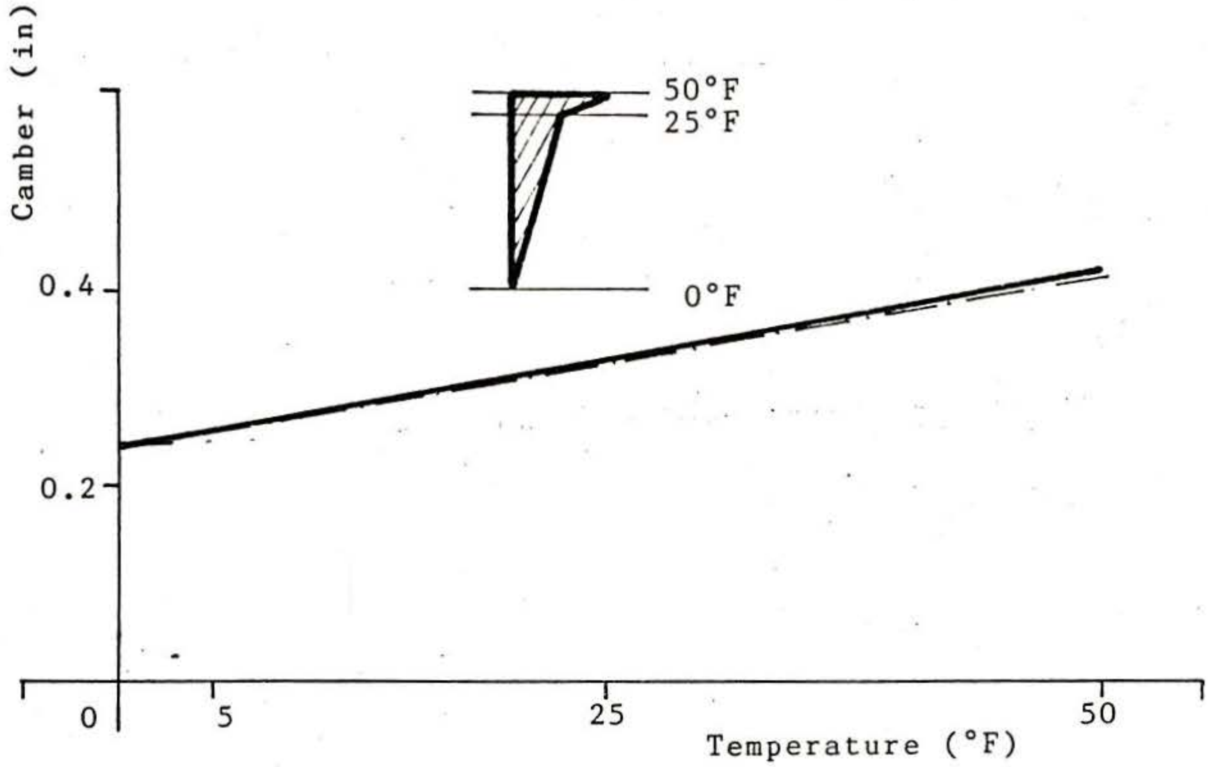
Fig 5.29 - Load-deflection responses under full span loading at ages of 28 days and one year.

increased when temperature varies across the depth of the beams, but under a constant temperature gradient no other effects are encountered.

(e) Unequal Spans

The use of different spans and smaller girders, see Fig. 5.17, by no means change the above conclusions. A similar behavior is found under different loading conditions as shown in Figs. 5.31, 5.32 and 5.33.

In conclusion, one may suggest that continuous-deck beams constitute a valid alternative solution for jointless bridge beams, either with steel or with precast concrete girders, for new construction or for the replacement of bridge decks. This new design concept shows promise as a method for achieving a jointless bridge deck.



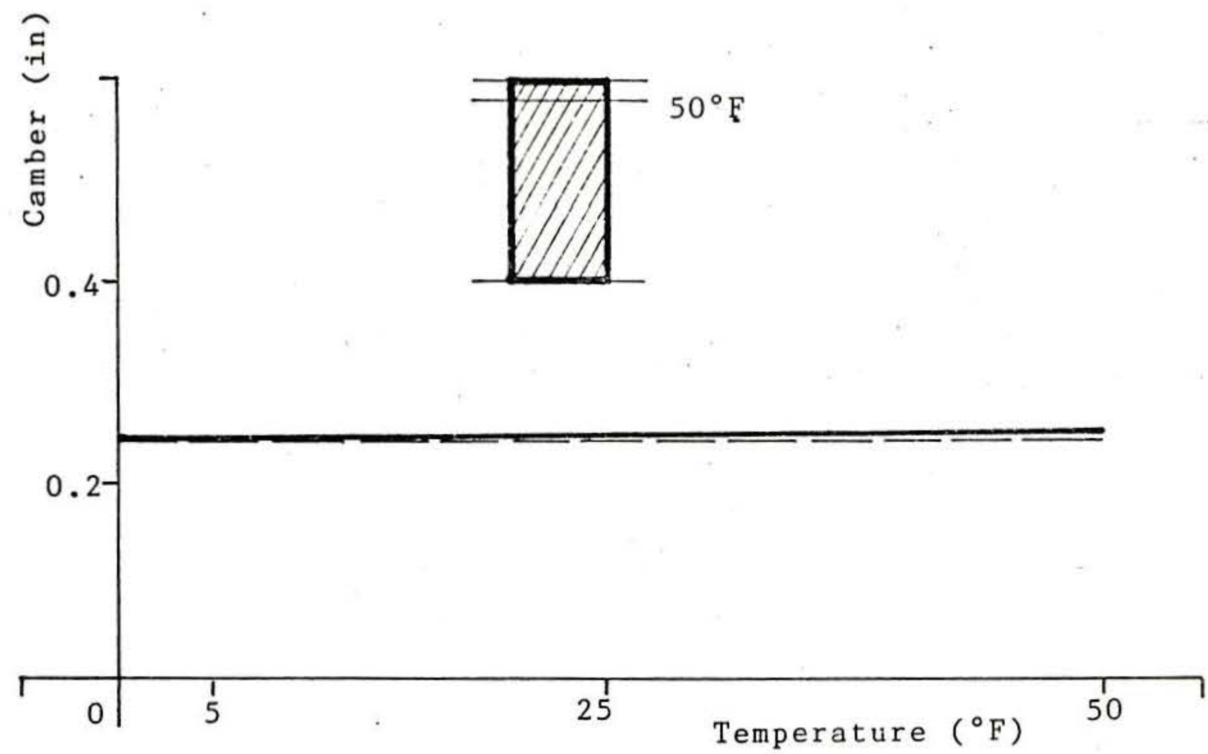


Fig 5.30 - Development of mid-span deflections under prestressing, dead load and temperature.

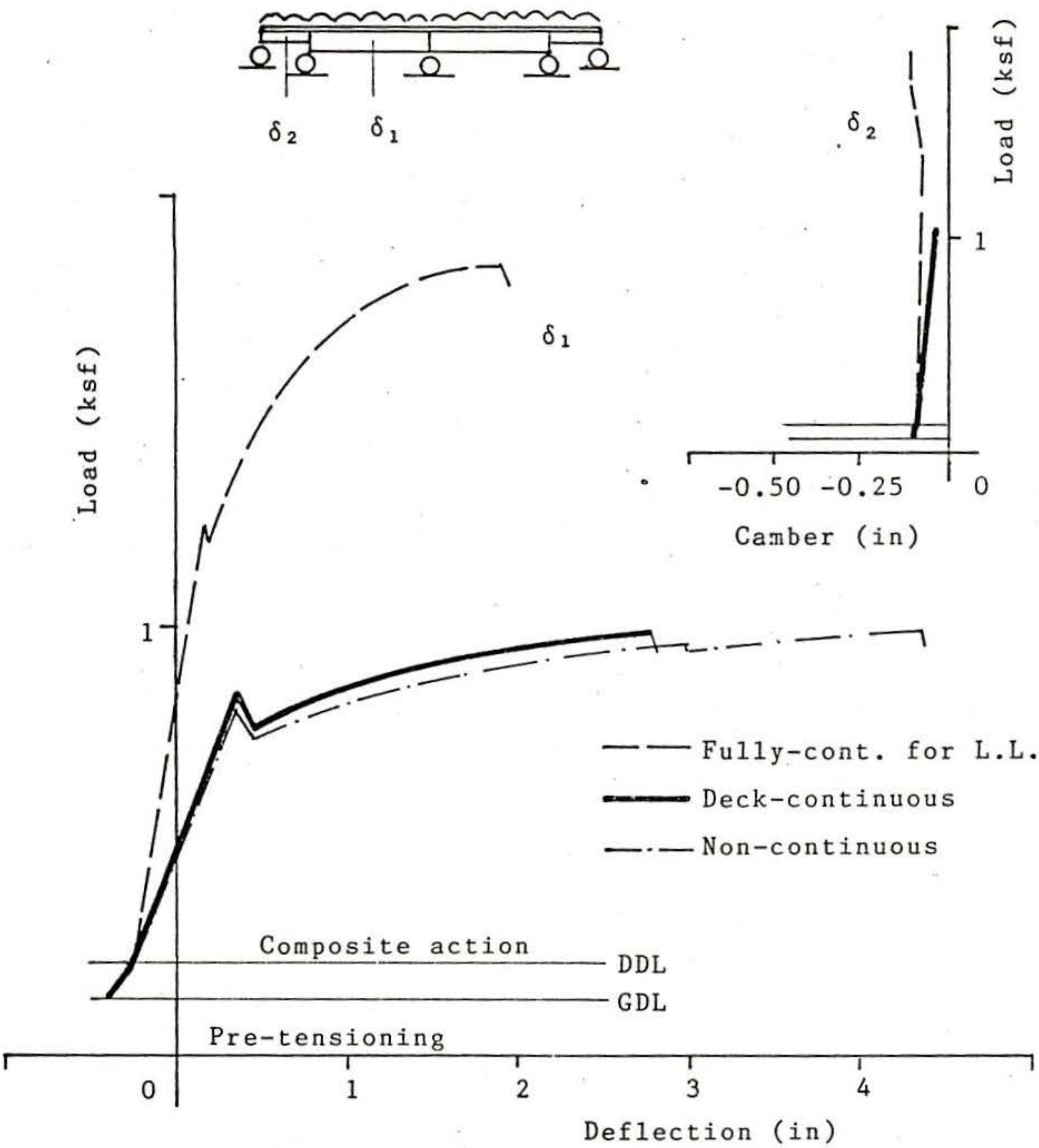


Fig 5.31 - Load-deflection responses under full span loading.

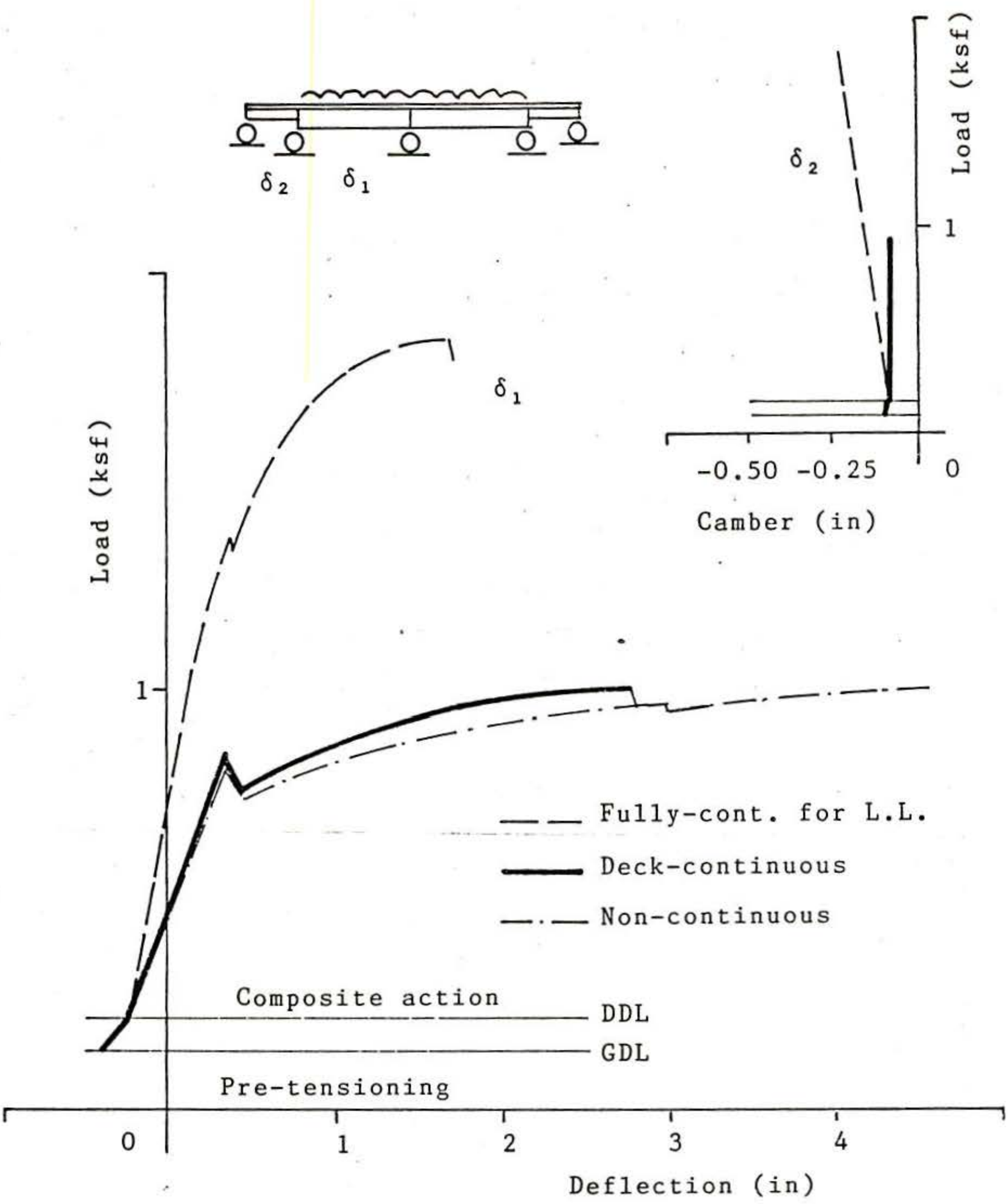


Fig 5.32 - Load-deflection responses for interior spans loading.

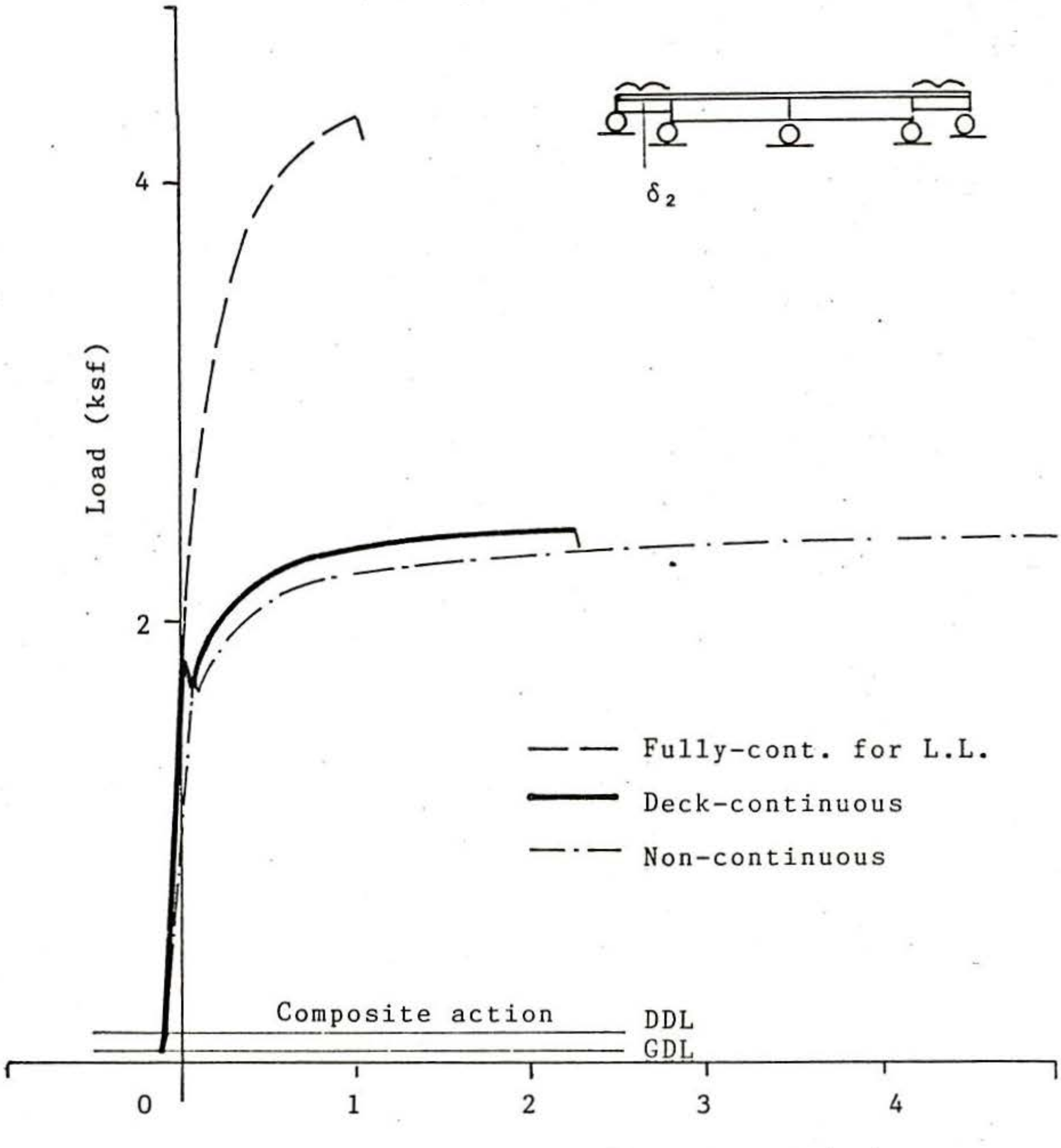


Fig 5.33 - Load-deflection responses for exterior spans loading.

6. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 Summary

The use of jointless construction is viewed as a new solution for the design of composite bridge beams. Expansion joints often become such a source of problems in maintaining bridges that their complete elimination seems preferable to some bridge designers. Among the few design solutions for a joint-free beam, the use of a fully-continuous deck slab over non-continuous girders appears a promising alternative. This solution is feasible not only for the construction of new bridges but also for the rehabilitation of old bridges requiring deck replacement.

The analysis of such beams is more complex than that of fully-continuous or non-continuous beams. However, numerical methods for structural analysis can be employed efficiently for either fully-continuous, non-continuous as well as deck-continuous beams. Instantaneous and time-dependent responses can be obtained for both linear and nonlinear ranges.

Many analytical and numerical solutions have been proposed by various investigators. Yet, none was found broad enough to completely suit the needs of the problem under consideration. It is the purpose of this study to propose a new numerical solution for the analysis of linear and nonlinear, instantaneous and time-dependent responses and strength of such beams. A finite element computer program has been developed for the analysis of both composite and non-composite, fully-continuous, non-continuous and deck-continuous bridge beams. Girders may be cast-in-place or precast, in steel, reinforced or prestressed concrete topped by a reinforced concrete deck slab. Prestressed girders may be pre- or post-tensioned, but with bonded tendons.

Different constructional procedures may be used and analyzed in any desirable sequence. The effects of dead and live loads, prestressing, support displacements and temperature variation as well as time-dependent effects of aging, creep, shrinkage and relaxation are taken into account. Two different methods are used for the application of external loads, by increments of load or displacement. Both the rate of creep method and the superposition method are used in estimating creep strains of concrete under variable stresses. A method similar to the rate of creep method is used in determining the relaxation of prestressing steel under varying stresses. The variation of the prestressing force due to deformation of the beam is also considered.

Different concrete materials may be used for deck slab and for girders. Either a bilinear or a Hognestad stress-strain relationship is assumed for concrete, and an elasto-plastic relationship is assumed for mild steel. For the prestressing steel, a trilinear relationship is assumed. The relationships for strength, creep and shrinkage of concrete, and relaxation of prestressing steel are based on the models proposed by the ACI Committee 209 and the PCI Committee on Prestress Losses. A smeared cracking model is used and concrete cracking is governed by a strain criterion.

The mechanical properties of the materials as well as the methods used for estimating instantaneous and time-dependent responses under uniaxial load are thoroughly described in Chapter 2. Chapter 3 describes in detail the formulations of two finite elements as well as the fundamental concepts used as the basis for the development of the proposed model. The capability and validity of the solution are demonstrated in Chapter 4. Ten example problems are presented in which eighteen different beams are analyzed and the results are compared with the experimental data reported in the literature.

The aplication of the proposed solution to deck-continuous beams is treated in Chapter 5. A two-span composite beam with steel girders and a four-span composite beam with prestressed concrete girders are analyzed therein. Various loadings, support conditions and arrangements, continuity and constructional scheme are studied.

6.2 Conclusions

Based on the results obtained, the following conclusion are drawn regarding the proposed model and the behavior of deck-continuous beams.

6.2.1 Model

(1) The possibility of obtaining both instantaneous and time-dependent responses in a single analysis is extremely useful in the determination of long-term strength of beams, i.e. the strength of beams that under long-time sustained load are eventualy subjected to its failure load.

(2) The use of two methods for application of loads, by increments of load and increments of displacement, has shown to be very convenient

for the study of different loading conditions. The Displacement Increment Method is capable of capturing the whole range of structural response, up to ultimate.

(3) Good agreement is found between measured and predicted results under the assumption of different stress-strain relationships for concrete. The models for aging, creep, shrinkage and steel relaxation together with the rate of creep and the superposition methods for estimating creep strains under variable stresses, have enabled reasonable predictions of time-dependent responses.

(4) The smeared cracking model for concrete presented a good performance in representing the post-cracking behavior of reinforced and prestressed concrete members.

(5) Both adopted elements have performed very adequately. The beam element with its variable nodal position enables the determination of horizontal reactions of bihinged beams under vertically applied load. Due to this inportant feature, it is possible to consider the actual horizontal movement of supports and its effect on the behavior of beams, especialy deck-continuous beams. The performance of the connection element is yet to be validated by experimental data.

6.2.2 Deck-Continuous Beams

(1) The responses of jointless deck-continuous beams have been observed to be governed primarily by the imposed boundary conditions.

(2) When steel girders are used for which hinged supports are not a difficult task, a deck connection tensile behavior may be achieved by

having a hinge of an adequate shearing capacity at each side of the connection, i.e. for both adjacent girders. A couple will be created at this section, through the deck connection and hinges, and negative or positive moments can be resisted nearly as well as if full continuity were provided. The beam has its response enhanced remarkably and under service loads may be compared to a fully-continuous beam. Under overload conditions more deflections and less strength can be expected; however, this may be corrected by increasing the amount of mild reinforcement.

(3) More ductility may be obtained by increasing the width of the deck connections, either by widing the space between girders or by providing some unbonded length between deck and girders, at each side of the support.

(4) For girders which are simply supported on bearing pads, as are precast prestressed concrete beams, tension is obtained at the deck connections. In this case a deck-continuous beam behaves very similarly to a jointed non-continuous beam, with stiffness slightly enhanced and with the advantage of having no undesirable joints.

(5) In prestressed concrete deck-continuous beams under overload conditions, cracking will occur at the deck connection; but under unloading, cracks are likely to close completely. Should cracks remain unclosed, they should be less damaging than a built-in joint.

(6) Failure of deck-continuous beams eventually occurs by extensive yielding of the reinforcement in the connection and after that the beams behave like a jointed beam, observing all its ducility and strength

properties.

(7) Under sustained loading, due to time effects such as aging, differential creep, differential shrinkage and steel relaxation, and also under temperature variation, the behavior of a deck-continuous beam does not show significant difference from those presented by the correspondent fully-continuous and non-continuous beams. Their long-term strength is also unchanged.

6.3 Recommendations for Further Research

The study of this new type of beams deserves a more extensive investigation. The study presented herein has served only as a first step, a preliminary analysis, which must be improved and extended by other investigators. Some suggestions for further research follow.

(1) The use of prestressing in the deck slab.

(2) The use of pre- and post-tensioning in the same structure, often used for dead load carrying.

(3) The inclusion of the tension stiffening effect found in concrete under cracked conditions.

(4) The inclusion of the bending stiffness of the deck within the connection elements.

(5) The effects of differential creep, differential shrinkage, steel relaxation and temperature variation in long multi-span beams with little or no joints.

(6) The investigation of an optimum span length of deck-continuous beams.

(7) It is finally and strongly suggested that some experimental work be done for obtaining a more reliable source of information on the behavior deck-continuous beams.

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8.1 Input and Output Guide

The input data are arranged in 24 different lines or sets of lines containing all the information necessary for the analysis of one or more problems at a time. A sample input is shown in Appendix C. The details for each entering are given below together with the necessary explanation pertaining each type of information. Data are to be input following the last card of the program coding. No blank lines are accepted and free format is to be used. Any desirable physical dimentioning may be used provided it is consistent throughout each problem.

1st line

Number of problems to be analyzed.

2nd line

A sequence of eight different enterings is contained in this single line, corresponding to the following variables:

a) Total number of elements.

b) Number of connection elements.

c) Number of nodal points.

d) Number of supports.

e) Number of loading cases, according to line 17.

f) Number of layers to be used in the girders. For rectangular or steel I-girders a multiple of 6 and for concrete I-girders a multiple of 4.

g) Number of layers to be used in the deck, any number.

h) Number of elements for which a complete information is to be printed. This information is updated at every step of the solution and contains: position, area, strain, stress and instantaneous modulus of elasticity for each of the layers. For every step of the solution, and corresponding to the chosen elements, the following results will be listed at the end of the output: bending moment, curvature, deflection, fraction of the applied load, current time of loading and number of iterations in the step.

3rd line

In a single line the numbers of all the elements chosen (line 2h) are to be listed.

4th line

Stiffnesses of the bearing pads, calculated according to section 2.4.

5th line

When the Displacement Increment Method is used for the application of the live load (line 17), three different entering are necessary for establishing:

a) Displacement increment to be applied at every incremental step. This displacement may be positive or negative according to the deflection presented by the structure at the particular nodal point, under the applied live load.

b) Number of the nodal point at which the incremental displacement (item a) is to be applied.

c) Fraction of the total live load to be applied.

6th line

Five integer values are needed for defining girder material, section type and variability, reinforcement distribution and concrete stress-strain relationship as follows.

a) Girder material: (0) steel, (1) prestressed concrete and (2) reinforced concrete.

b) Girder cross-sectional type: (0) rectangular and (1) other shapes like I, Tee, double Tee and box girders.

c) Dimentions of the girder cross-sections along the length of the: (0) constant and (1) variable.

d) Reinforcement distribution along the length of the beam: (0) constant and (1) variable.

e) Assumed stress-strain relationship for concrete: (0) Hognestad's and (1) bilinear.

7th line

For establishing the dead loads of the girders and deck the specific weights of the materials are needed. Two values are to be entered in one single line, calculated according to the chosen physical dimentions and corresponding to girders and deck respectively.

8th line

For establishing the ages of the materials and the consequent effects of creep, shrinkage and relaxation five time values, in days, are to be input in one single line and corresponding to:

a) Time at which the curing of the girder concrete has ended. 28

b) Time at which the curing of the deck concrete has ended.

c) Time at which the girders have been first loaded. 28

d) Time at which the deck has been first loaded.

e) Time of prestressing. 28

Lines 9 to 12 correpond to setting of material properties. All six enterings for each line are to be assumed as positive and their proper signs will be assigned inside the program.

9th line

According to Fig. 2.6, the tri-linear stress-strain relationship for the prestressing steel is established by the setting of six different variables. The first three correspond to the modulii of elasticity of the three linear segments, the following two define the two yielding stresses, fs1 and fs2, and the last one defines its ultimate strain.

10th line

The bilinear stress-strain relationship of reinforcing steel, Fig. 2.5, is defined by the variables: initial modulus of elasticity, yielding strain and ultimate strain.

11th line

The girders may be made of steel or concrete. For steel girders the stress-strain relationship of its material is input in a similar fashion as in line 10 for steel reinforcement. For the concrete girders four variables are used in defining the stress-strain relationship of concrete: Initial modulus of elasticity, 28-day cylinder strengh, tensile rupture strain and ultimate compressive strain.

12th line

The variables used for defining the stress-strain relationship of concrete used in the deck slab are input similarly as the ones for the girder concrete, as in line 11.

13th line

As many lines as the number of elements are needed for defining the connectivity and the type of each element used. Three entering are used in each line. The first two define the number of the two nodal points and the last defines the type of the element as follows:

(0) A beam element defined at the begining of the solution, representing the girder and deck cross-sections.

(1) A connection element defined at the time when the deck slab is cast and its stiffness is added to the girder stiffness.

(2) A beam element used for obtaining continuity for live load. The element will be defined when the deck slab is cast and continuity is obtained. Its dimentions may be different from the other beam elements for representing a diaphragm for instance.

14th line

Coordinates and nodal conditions are defined by five enterings in as many lines as there are nodal points. The first two numbers define the horizontal and vertical coordinates of each nodal point, respectively. The origin of the horizontal coordinates may be located at any desirable position, but the vertical coordinates are refered to the bottom face of each girder.

The nodal conditions represent the restrictions applied to each nodal point in each of the three directions, i.e. horizontal, vertical and rotational directions respectively as: (0) free and (1) restricted.

15th line

When the dimentions of the cross-sections of the elements are constant throughout the length of the member, see line 6c, only one line is needed for the input of the sectional dimentions. Otherwise, as many lines as there are elements are needed. The following cases apply for each type of cross-section:

a) Steel I-girders - Eight enterings define the dimentions of the deck and girders, in the following order: deck width and thickness; girder area, depth and moment of inertia; thicknesses of the top flange, web and botton flange.

b) Rectangular cross-section - Only four enterings are used: deck width and thickness, and girder width and thickness.

c) Girders of other shapes - Any other shape of the girders is modeled as an I cross-section. Width and thickness of the deck, top flange, web and bottom flange are input in a similar sequence.

d) Connection element - For the deck connection, and only when variable cross-sections are used, see line 6c, four enterings are needed: width and thickness of the deck and distances from the C.G.C. of the deck to the bottom faces of the two adjacent girders.

16th line

Three levels of reinforcement may be used, one in the deck slab and two in the girders. Total area and position of each level with respect to the bottom face of the girders are defined by six enterings. When constant steel distribution is used, see line 6d, only one line is needed. Otherwise, as many lines as there are elements are input. The first reinforcement level is defined as the one in the deck, the second and third following downards, respectively.

17th line

Each loading condition, instantaneous or time-dependent, is defined by a line containing eight integer enterings:

a) A number defining the type of loading, load case, according to the following list:

1 Girder dead load

2 Prestressing

3 Deck dead load

4 Support displacements

5 Live load

6 Temperature

7 Time effects

b) A variable, 0 or 1, defining whether the beam is to be assumed noncomposite or composite, respectively, for each load case.

c) Number of steps to be used in each loading. For prestressing one step is assumed and when using the Displacement Increment Method the variable shall be assigned the value 1000.

d) A variable, 1 or 0, defining whether the results for each step shall be printed or not, respectively. For the last step of each load case the results are always printed regardless of the value assumed.

e) A variable defining which time-effects are to be analyzed.

0 None

1 Creep

2 Shrinkage

3 Relaxation

4 All

f) Time at which the loading case is to be initiated, in days.

g) Time at which the loading case is to be finished, in days.

h) A variable, 1 or 0, defining whether the bearing supports are to be transformed into hinges or not, respectively. This effect is obtained by assigning a very large stiffness to the bearing supports.

18th line

In as many lines as there are supporting nodes two variables shall define: the number of the supporting nodal point and magnitude of vertical displacements to be applied at the respective supports.

19th line

A temperature variation gradient is defined by three temperature values at the top of the deck slab, at the deck-girder interface and at the bottom of the girders, respectively.

20th line

In as many lines as there are nodal points three concentrated nodal loads may be defined, in the horizontal, tranversal and rotational directions respectively.

21st line

Loads applied at the elements are defined by three enterings in as many lines as there are elements: A uniformly distributed load, and a concentrated load and its point of application, measured from the left nodal point, respectively.

Lines 22 to 25 regard information concerning the prestressing cables and their characteristics. They shall be omitted when the girders are not prestressed.

22nd line

One single line with six enterings is used for defining the following prestressing variables:

a) Type of prestressing, (0) post-tensioned and (1) pre-tensioned.

b) Type of cable profile, (0) straight, (1) parabolic and (2) other.

c) Number of prestressing segments, defined by beginning and end of each segment.

d) Friction coefficient.

e) Wobbling coefficient.

f) Type of steel, (0) low-relaxation and (1) stress-relieved.

23rd line

In as many lines as there are prestressing segments, see line 22c, five enterings are used to define:

a) Number of the element at which the prestressing segment starts.

b) Number of the element at which the prestressing segment ends.

c) Cross-sectional area of the tendons.

d) Initial prestressing force.

e) Side of the prestressing segment at which the cable will be pulled: (1) left and (2) right, used for the calculation of friction losses.

24th line

When the assumed cable profile is either straight or parabolic, see line 22b, three nodal points are chosen to define the cable profile. In as many lines as there are prestressing segments the number of the nodal points and the distances from the cable to the bottom face of the girders, at those nodal points, are to be defined for each chosen node, respectively. When the cable profile is defined as other the vertical position of the cable shall be informed at each node, in as many lines as there are nodes.

The program output as shown in Appendix D, is divided into two sections: the first section refers to the input properties of each problem. It is repeated as many times as the number of problems analyzed and follows the same order used for data input, as explained in lines 1 through 24. The second section immediately follows, it presents all the results obtained by the finite element program and it is subdivided into the following subsections:

(1) Global displacements - For each and all nodal points a global displacement number is assigned, in crescent order and skipping the prescribed degrees of freedom for which a zero is assigned.

(2) Storage needed - The total storage capacity needed for each problem is calculated. If the number is considerably different then the provided storage capacity, shown in the first output section, the latter may be changed accordingly.

(3) Dead load - Dead load of the girders and deck are separetely calculated and printed out for each of the elements.

(4) Original section properties - Transformed section properties, centroidal position, area and moments of area, are calculated for both possible situations: noncomposite and composite sections. Those properties refer to the original uncracked sections and are printed for all elements.

(5) New section properties - Updated section properties are printed at every new load case and step. Those properties reflect any changing of the material properties as well as cracking development at the sections.

(6) Nodal displacements - At every increment step, displacements for the step and the total accumulated displacements are printed for all nodal points and for the three possible directions, horizontal, transversal and rotational, respectively.

(7) Element forces - The total updated forces, axial, moment and shear, are calculated and printed for all elements, at every step. Those forces reflect the action of the external loading, reactions and prestressing effects as well.

(8) Reactions - Nodal external reactions, at all nodal supports, are calculated for the three directions and printed at every loading step.

(9) Prestressing cable properties - For all the elements under prestressing, the updated forces, stresses, strains and instant elastic modulii are calculated and printed at every loading step. This section is ommitted in non prestressed problems.

(10) Strains - For all elements and at every loading step the updated and the maximum strains reached at the top and bottom surfaces of the girders and deck are printed, respectively.

(11) Cracking - For all elements and at every loading step, cracking length is printed for both girders and deck, starting from the top and bottom surfaces, respectively.

(12) Cracking layout - A complete cracking layout is printed for every loading step. For all elements and layers cracking is represented by 0's and uncracked layers by 1's.

(13) Crack angles - For all elements and layers the angles formed by the cracks with the horizontal direction are printed out, approximated by the nearest integer angle.

(14) Reinforcement stresses - Stresses at the three reinforcement levels, in the deck, top flange and bottom flange of the girders,

respectively, are printed at every load step and for all elements.

(15) Yielding layout - For all three reinforcement levels and all layers of a steel girder, a complete layout of yielding is printed by representing yielded layers by 0's. Similarly as for the cracking layout this is updated at every loading step.

(16) Checking elements - For all the chosen checking elements, see line 2h, and at every layer, centroidal position of the layer, cross-sectional area of the layer, stress, strain and instant modulus of the material are printed.

(17) Moment-curvature-deflection - After all loading steps are printed, a complete list of bending moments, curvatures, deflections, fraction of the applied load, current times and number of iterations are shown for all of the loading steps and every chosen checking elements. This list is immediately followed by a message indicating the reason for which the problem has been terminated.

(18) Support reactions - A complete list of the support reactions is printed for all supports and every loading step.

(19) Plots - Plots of the moment-curvature and moment-deflection distributions are available for each and all of the chosen checking elements.

8.2 Listing of the Program

```
C*****************************************************************
C                V A R I A B L E S    I N D E X                  *
C*****************************************************************
C                                                                *
C  IGMAT = MATERIAL OF THE GIRDER ( STEEL, PC, RC )              *
C IATYPE = SECTION SHAPE (RECT., I OR T OR BOX )                 *
C  ICOMP = COMPOSITE SECTION OR NOT                              *
C ICONST = CONSTANT CROSS SECTION, OR VARIABLE                   *
C  GAMAG = UNIT WEIGHT OF THE GIRDER MATERIAL                    *
C  GAMAD = UNIT WEIGHT OF THE DECK MATERIAL                      *
C   ISSC = STRESS-STRAIN CURVE                                   *
C     BC = BEARING STIFFNESS COEFFICIENT                         *
C DRIVLL = LIVE LOAD DRIVEN BY : LOAD=0, DISP (NOT=) 0           *
C   NODR = NODE OF THE DRIVING DISPLACEMENT                      *
C   AK22 = S.M. DIAGONAL TERM FOR THE D.D.M.                     *
C     P2 = NODAL LOAD AT THE DRIVING DISP.                       *
C  ALPHA = LIVE LOAD FRACTION                                    *
C  ALPLL = LIVE LOAD UPPER LIMIT                                 *
C    NEL = NUMBER OF ELEMENTS                                    *
C   NNOD = NUMBER OF NODES                                       *
C   NCEL = NUMBER OF CONECTION ELEMENTS                          *
C  NCHEL = NUMBER OF CHECKING ELEMENTS                           *
C   NSUP = NUMBER OF SUPPORTS                                    *
C  NLOCA = NUMBER OF LOAD CASES                                  *
C    NGL = NUMBER OF GIRDER LAYERS                               *
C    NDL = NUMBER OF DECK   LAYERS                               *
C     AP = DISTANCE OF CONC. VERT. LOAD FROM LEFT NODE           *
C  H1,H2 = DISTANCES FROM CENTROID OF THE 'CE' TO                *
C          BOTTOM OF THE ADJACENT ELEMENTS                       *
C  NDISP = NUMBER OF GLOBAL DISPLACEMENTS                        *
C NNDISP = NEW NDISP, WITHOUT THE DRIVING DISP.                  *
C  NBAND = SEMI BAND WIDTH                                       *
C    NEQ = NUMBER OF UNKNOWN DISPLACEMENTS ( NDISP )             *
C  IPRET = PRESTR. MODE, (0)POSTENSIONED   (1)PRETENSIONED       *
C  IPROF = CABLE PROFILE, (0)STRAIGHT (1)PARABOLIC (2)OTHER      *
C    NPS = NUMBER OF PRESTRESSED SEGMENTS                        *
C  IPULL = JACKING SIDE ( 1 LEFT, 2 RIGHT )                      *
C  FM,FK = FRICTION COEFFICIENTS                                 *
CERG,ERD = RUPTURE STRAIN: GIRDER AND DECK                       *
C IT1,.. = TEMPERATURE VARIATION - BILINEAR                      *
C    IST = STEEL TYPE, 0=LOW RELAX.  1=STRESS RELIEVED           *
C                                                                *
C*****************************************************************
C              A R R A Y S    I N D E X                          *
C*****************************************************************
C                                                                *
C    DIM = DIMENTIONS OF THE SECTION                             *
C   CDIM = DIMENTIONS OF THE CONSTANT CROSS SECTION              *
C  STEEL = STEEL CONTENT ( AREA AND POSITION )                   *
C      E = ALL MATERIAL PROPERTIES                               *
C   AREA = SECTION PROPERTIES (YB,A,AM,MI,EA,ES,EI,GA)           *
C      X = GLOBAL NODE COORDINATES, Y ZERO AT BOTTOM             *
C    XEL = COORDINATES OF NODES OF EACH ELEMENT                  *
C     ST = GLOBAL STIFFNESS MATRIX                               *
C   ELST = ELEMENT STIFFNESS MATRIX                              *
C   IVAR = NODAL CONDITION, FIXED AND FREE                       *
C   NVAR = GLOBAL DISPLACEMENT NUMBERS                           *
C   KVAR = GLOBAL DISP. NUM. FOR THEN D.D.M.                     *
C    IEL = INCIDENCE OF NODES IN EACH ELEM., ELEM.TYPE           *
C   DISP = DISPLACEMENTS FOR THIS STEP                           *
C  SDISP = TOTAL NODAL DISPLACEMENTS                             *
C    CNF = CURRENT NODAL FORCES  (1: UP TO LAST LOAD CASE        *
C                                 2: CURRENT                     *
C                                 3: TOTAL THIS LOAD CASE )      *
C  FORCE = SECTION FORCES, TOTAL, FROM EQUILIBRIUM               *
C  ALOAD = NODAL APPLIED LOADS                                   *
C APLOAD = ELEMENT APPLIED LOADS                                 *
C  ELOAD = ELEMENT EQUIVALENT NODAL FORCES                       *
C  CLOAD = NODAL FORCES                                          *
C  DLOAD = DISTRIBUTED FORCES                                    *
C    DCL = RESISTING NODAL FORCES                                *
C   REAC = SUPPORT REACTIONS                                     *
C RELIST = LIST OF SUPPORT REACTIONS FOR ALL STEPS               *
C   LOCA = LOAD CASES AND CONSTRUCTIONAL PATTERN                 *
C PREDIS = PRESCRIBED DISPLACEMENTS AT SUPPORTS                  *
C      B = NODAL FORCES , NODAL DISPLACEMENTS                    *
C YCABLE = PRESTR. CABLE POSITION AT THE NODES                   *
C  CABLE = CABLE PROPERTIES AT THE ELEMENTS                      *
C FINCAB = INIT. CABLE FORCES,MOM.,SHEAR, AFTER FR. LOSSES       *
C CABSST = INITIAL CABLE STRAINS (IN A STEP)                     *
C    STP = SHEAR STRAINS UP TO PRESTRESSING                      *
C  PSEGM = PROPERTIES OF EACH PRESTRESSED SEGMENT                *
C  ELONG = CABLE LENGHT AND ELONGATION                           *
C    PRF = PARABOLIC OR STRAIGHT CABLE PROFILE                   *
C      Y = SECTION LAYERS: CENTROID, AREA AND WIDTH              *
C    STA = STRAIN AT CENTER LAYERS AND REINF. STEEL              *
C   STRB = STRAIN AT SECTION BORDERS                             *
C  STRST = STRAINS ONLY FOR THIS STEP                            *
C  STREL = TOTAL ELASTIC STRAINS                                 *
C  STRLC = ELASTIC STRAIN IN THE LOAD CASE                       *
C  EPERM = PLASTIC STRAIN IN CONCRETE AT CRACKING                *
C   STRE = STRESSES AT LAYERS AND REINF. STEEL                   *
C  CRACK = VERTICAL CRACKS AT THE ELEMENTS                       *
C ICRACK = CRACKS AT THE LAYERS                                  *
C IALPHA = CRACK ANGLE AT THE LAYERS                             *
C   IELD = YIELDING AT STEEL GIRDER AND REINF. STEEL             *
C   EALL = ELASTIC MOD. FOR CONCR. AND REINF. STEEL              *
C          AT ALL ELEM. AND LAYERS, THROUGH TIME                 *
C ICHECK = CHECKING ELEMENTS                                     *
C   AK12 = S.M. ROW FOR THE DRIVING DISP.                        *
C     P1 = LOAD VECTOR FOR THE D.D.M.                            *
C      T = CURRENT AND FIXED TIMES                               *
C                                                                *
C*****************************************************************
      IMPLICIT REAL*8(A-H,O-Z)
      REAL*4 XX(300),YY(300)
      DIMENSION A(20000),IA(5000),E(4,6),CDIM(8),PSEGM(10,5),
     *          Y(50,3),T(6)
      READ(1,*)NDATA
      DO 999 IJK=1,NDATA
      WRITE(3,2222)
      WRITE(3,2222)
 2222 FORMAT(/,130('*'),/)
      WRITE(3,3000)IJK
 3000 FORMAT(//,50X,'EXAMPLE #',I2,//)
      WRITE(3,2222)
      LIMITP=20000
```

```
      WRITE(3,1000)LIMITP
 1000 FORMAT(1X,'STORAGE PROVIDED = ',I10)
      WRITE(3,2222)
      WRITE(3,2000)
 2000 FORMAT(/,45X,'   I N P U T    D A T A   ',/)
      WRITE(3,2222)
      READ(1,*)NEL,NCEL,NNOD,NSUP,NLOCA,NGL,NDL,NCHEL
      NSUP3=NSUP*3
      NL=NGL+NDL
      NS1=NL+4
      NS2=NL+4
      NS3=NL+3
      NS4=NGL+3
      NCH3=NCHEL*6
C..........................NON INTEGER ARRAYS................
C
      N1=1
C..................(N1-N2) COORDINATES ( X )
      N2=1+NNOD*2
C..................(N2-N3) APPLIED NODAL LOADS ( ALOAD )
      N3=N2+NNOD*3
C..................(N3-N4) NODAL FORCES, DISPLACEMENTS ( B )
      N4=N3+NNOD*3
C..................(N4-N5) APPLIED ELEMENT LOADS ( APLOAD )
      N5=N4+NEL*3
C..................(N5-N6) SUPPORT REACTIONS ( REAC )
      N6=N5+NSUP*3
C..................(N6-N7) SECTION DIMENTIONS ( DIM )
      N7=N6+NEL*8
C..................(N7-N8) STEEL CONTENT ( STEEL )
      N8=N7+NEL*6
C..................(N8-N9) SECTION PROPERTIES ( AREA )
      N9=N8+NEL*8
C..................(N9-N10) DEAD LOAD ( DELO )
      N10=N9+NEL*2
C..................(N10-N11) NODAL FORCES ( CLOAD )
      N11=N10+NNOD*3
C..................(N11-N12) DISTRIBUTED FORCES ( DLOAD )
      N12=N11+NEL*3
C..................(N12-N13) NODAL DISPLACEMENTS ( SDISP )
      N13=N12+NNOD*3
C..................(N13-N14)
      N14=N13
C..................(N14-N15) LOAD CASES ( LOCA )
      N15=N14+NLOCA*8
C..................(N15-N16) PRESCRIBED DISPLACEMENTS ( PREDIS )
      N16=N15+NSUP*2
C..................(N16-N17) CABLE POSITION ( YCABLE )
      N17=N16+NNOD
C..................(N17-N18) CABLE PROPERTIES ( CABLE )
      N18=N17+NEL*7
C..................(N18-N19) LAYER STRAINS, TOTAL ( STA )
      N19=N18+NEL*NS1
C..................(N19-N20) BORDER STRAINS, TOTAL ( STRB )
      N20=N19+NEL*8
C..................(N20-N21) STRAINS AT THIS STEP, LAYER ( STRST )
      N21=N20+NEL*NS2
C..................(N21-N22) CRACKING ( CRACK )
      N22=N21+NEL*8
C..................(N22-N23) ELASTIC MOD. VARIATION ( EALL )
      N23=N22+NEL*NS3
C..................(N23-N24) STRAINS AT CRACKING ( EPERM )
      N24=N23+NEL*NL
C..................(N24-N25) STRESSES ( STRE )
      N25=N24+NEL*NS3
C..................(N25-N26) CURRENT NODAL FORCES ( CNF )
      N26=N25+NNOD*9
C..................(N26-N27) TOTAL ELASTIC STRAINS ( STREL )
      N27=N26+NEL*NL
C..................(N27-N28) DISPLACEMENTS FOR THIS STEP ( DISP )
      N28=N27+NNOD*3
C..................(N28-N29) MOMENT-CURV-DISPL. ( DCM )
      N29=N28+NCH3*300
C..................(N29-N30) INCREM. FORCES ( DCL )
      N30=N29+NNOD*3
C..................(N30-N31) ELASTIC STRAINS IN THE L.C. ( STRLC )
      N31=N30+NEL*NL
C..................(N31-N32) SECTION FORCES ( FORCE )
      N32=N31+NEL*3
C..................(N32-N33) S.M. COLUMN ( K12 )
      N33=N32+NNOD*3
C..................(N33-N34) NEW LOAD VECTOR ( P1 )
      N34=N33+NEL*3
C..................(N34-N35) DISPLACEMENT VECTOR ( DU )
      N35=N34+NNOD*3
C..................(N35-N36) INITIAL CABLE FORCES ( FINCAB )
      N36=N35+NEL*3
C..................(N36-N37) INITIAL CABLE STRAINS IN STEP ( CABSST )
      N37=N36+NEL
C..................(N37-N38) SHEAR STRAINS UP TO PRESTR. ( GTP )
      N38=N37+NEL
C..................(N38-N39) LIST OFF REACTIONS ( RELIST )
      N39=N38+300*10
C..................(N39-   ) GLOBAL STIFFNESS MATRIX ( ST )
C
C.............................INTEGER ARRAYS.................
C
      M1=1
C...f...............(M1-M2) GLOBAL DISPLACEMENTS ( NVAR )
      M2=M1+NNOD*3
C..................(M2-M3) NODAL CONDITION ( IVAR )
      M3=M2+NNOD*3
C..................(M3-M4) ELEM'S INCIDENCE,TYPE ( IEL )
      M4=M3+NEL*3
C..................(M4-M5) CRACK AT THE LAYERS ( ICRACK )
      M5=M4+NEL*NL
C..................(M5-M6) CRACK ANGLE AT LAYERS ( IALPHA )
      M6=M5+NEL*NL
C..................(M6-M7) YIELDING ( IELD )
      M7=M6+NEL*NS4
C..................(M7-M8) CHECKING ELEMENTS ( ICHECK )
      M8=M7+NCHEL
C..................(M8-M9) NEW GLOBAL DISP FOR THE D.D.M. ( KVAR )
      M9=M8+NNOD*3
C
      LIMITI=M9
      WRITE(3,2100)NEL
 2100 FORMAT(1X,'NUMBER OF ELEMENTS =',I5,///)
      WRITE(3,2150)NCEL
 2150 FORMAT(1X,'NUMBER OF CONECTION ELEMENTS =',I5,///)
```

```
      WRITE(3,2200)NNOD
 2200 FORMAT(1X,'NUMBER OF NODES =',I5,///)
      WRITE(3,2250)NSUP
 2250 FORMAT(1X,'NUMBER OF SUPPORTS =',I5,/)
      WRITE(3,2222)
      CALL INPUT(NNOD,NSUP,NEL,E,A(N1),IA(M3),IA(M2),A(N4),A(N2),A(N3)
     *,NDISP,BC,A(N6),CDIM,A(N7),A(N8),IGMAT,IATYPE,ICONST,GAMAG,GAMAD
     *,NLOCA,A(N14),A(N15),A(N16),A(N17),IPRET,NPS,PSEGM,PM,PK,
     *NS3,A(N22),NGL,NL,IA(M7),NCHEL,ISSC,DRIVLL,NODR,ALPLL,IT1,IT2,
     *IT3,T,IST)
      CALL  BAND(NEL,IA(M3),NBAND)
      CALL GDISP(NNOD,IA(M1),IA(M2),NDISP)
      LIMITN=N39+NNOD*3*NBAND
      NODE3=NNOD*3
      WRITE(3,2222)
      LIMIT=LIMITN+LIMITI
      WRITE(3,1500)LIMIT
 1500 FORMAT(1X,' STORAGE NEEDED = ',I15)
      IF(LIMIT.LE.LIMITP)GO TO 99
      WRITE(3,1600)
 1600 FORMAT(3X,'THE PROGRAM HAS TERMINATED SINCE THE
     *PROVIDED STORAGE IS NOT SUFFICIENT '//)
      CALL EXIT
   99 CONTINUE
      CALL CONSTR(IGMAT,IATYPE,NLOCA,GAMAG,GAMAD,NNOD,NSUP,NEL,NCEL,
     *NODE3,NDISP,NBAND,E,BC,IA(M1),IA(M2),IA(M3),A(N1),A(N2),
     *A(N3),A(N4),A(N5),A(N6),A(N7),A(N8),A(N9),A(N10),A(N11),A(N12)
     *,A(N14),A(N15),A(N16),A(N17),IPRET,NPS,PSEGM,PM,PK,
     *ICONST,A(N18),A(N19),A(N20),A(N21),NGL,NL,NS1,NS2,NS3,NS4,
     *A(N22),Y,IA(M4),IA(M5),IA(M6),A(N23),A(N24),A(N25),IA(M7),
     *NSUP3,A(N27),A(N28),A(N29),A(N31),A(N26),A(N30),A(N32),
     *A(N33),IA(M8),A(N34),A(N35),A(N36),A(N37),A(N38),A(N39),NCHEL,
     *NCH3,ISSC,DRIVLL,NODR,AK22,ALPLL,ITNST,IT1,IT2,IT3,T,IST)
      CALL PLOT(XX,YY,A(N28),ITNST,NCH3,IA(M7),NCHEL)
  999 CONTINUE
      STOP
      END
C ************************************************************

      SUBROUTINE INPUT(NNOD,NSUP,NEL,E,X,IEL,IVAR,APLOAD,ALOAD,B
     *                ,NDISP,BC,DIM,CDIM,STEEL,AREA,IGMAT
     *                ,IATYPE,ICONST,GAMAG,GAMAD,NLOCA,LOCA,
     *                PREDIS,YCABLE,CABLE,IPRET,NPS,PSEGM,PM,PK,
     *NS3,EALL,NGL,NL,ICHECK,NCHEL,ISSC,DRIVLL,NODR,ALPLL,IT1,IT2,
     *IT3,T,IST)
C *************************************************************
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION X(NNOD,2),IVAR(NNOD,3),IEL(NEL,3),DIM(NEL,8),CDIM(8)
     *         ,B(1),ALOAD(NNOD,3),APLOAD(NEL,3),STEEL(NEL,6)
     *         ,E(4,6),AREA(NEL,8),LOCA(NLOCA,8),PREDIS(NSUP,2)
     *         ,YCABLE(NNOD),CABLE(NEL,7),PSEGM(10,5),PRF(10,6)
     *         ,EALL(NEL,NS3),ICHECK(NCHEL),T(6)
      IF(NCHEL.GT.0)THEN
      READ(1,*)(ICHECK(I),I=1,NCHEL)
      END IF
      READ(1,*)BC
      READ(1,*)DRIVLL,NODR,ALPLL
      WRITE(3,2300)
 2300 FORMAT(10X,'P R O P E R T I E S ')
      WRITE(3,1111)
 1111 FORMAT(/,130('-'),/)
      WRITE(3,2310)
 2310 FORMAT(29X,'0',17X,'1',16X,'2',//,1X,'GIRDER MATERIAL',8X,
     *          'STEEL',13X,'PREST. CONC',7X,'REINF. CONC',//,
     *          1X,'GIRDER TYPE ',11X,'RECTANGULAR',7X,'I,T OR BOX',//,
     *          1X,'SECTION DIMENTIONS',5X,'CONSTANT',10X,'VARIABLE',//,
     *          1X,'STEEL DISTRIBUTION',5X,'CONSTANT',10X,'VARIABLE',//,
     *          1X,'COMPOSITE SECTION',6X,'NON COMP.',9X,'COMPOSITE',//,
     *          1X,'STRESS-STRAIN CURVE',4X,'HOGNESTAD',9X,'BILINEAR')
      WRITE(3,1111)
      WRITE(3,2400)BC
 2400 FORMAT(/,1X,'BEARING COEF.=',D15.5,//)
      READ(1,*)IGMAT,IATYPE,ICONST,ISTEEL,ISSC
      READ(1,*)GAMAG,GAMAD
      T(1)=28
      READ(1,*)(T(I),I=2,6)
      WRITE(3,120)GAMAG,GAMAD
  120 FORMAT(1X,'GIRDER MAT. UNIT WEIGHT =',D15.8,//,
     *          1X,'DECK MAT. UNIT WEIGHT =',D15.8,//)
      WRITE(3,1)IGMAT,IATYPE,ICONST,ISTEEL,ISSC
    1 FORMAT(1X,'GIRDER MATERIAL=',I2,//,
     *          1X,'SECTION TYPE=',I2,//,
     *          1X,'SECTION DIMENTIONS=',I2,//,
     *          1X,'STEEL DISTRIBUTION=',I2,//,
     *          1X,'STRESS-STRAIN CURVE=',I2,//)
      WRITE(3,9)T(2),T(4),T(3),T(5),T(6)
    9 FORMAT(1X,'TIME LIST :',5X,'GIRDER CASTING',5X,D10.3,'  DAYS',//,
     *                        17X,' " 1ST LOADING',5X,D10.3,'   "  ',//,
     *                        17X,' DECK  CASTING',5X,D10.3,'   "  ',//,
     *                        17X,' " 1ST LOADING',5X,D10.3,'   "  ',//,
     *                        18X,' PRESTRESSING ',4X,D10.3,'   "  ')
 2222 FORMAT(/,130('*'),/)
      DO 121 I=1,4
      READ(1,*)(E(I,J),J=1,6)
  121 CONTINUE
      DO 123 I=1,NEL
      DO 124 J=1,NGL
      EALL(I,J)=E(3,1)
  124 CONTINUE
      LIM=NGL+1
      DO 125 J=LIM,NL
      EALL(I,J)=E(4,1)
  125 CONTINUE
      DO 126 J=1,3
      EALL(I,NL+J)=E(2,1)
  126 CONTINUE
  123 CONTINUE
      WRITE(3,2222)
      WRITE(3,70)
   70 FORMAT(15X,'M A T E R I A L   P R O P E R T I E S ')
      WRITE(3,1111)
      WRITE(3,71)
   71 FORMAT(3X,'P/S : E0,  E1,  E2, SY1, SY2, EU',//,
     *          3X,'R/S : E0,  EY,   0,   0,   0, EU',//,
     *          3X,'G/S : E0,  EY,   0,   0,   0, EU',//,
     *          1X,'G/C : E0, FC1,  EB,   0,   0, EU',//,
     *          3X,'D/C : E0, FC1,  EB,   0,   0, EU',//)
      WRITE(3,1111)
      WRITE(3,72)(E(1,I),I=1,6)
   72 FORMAT(1X,'PREST.STEEL:',6(3X,D12.5),/)
```

```
      WRITE(3,73) (E(2,I),I=1,6)
   73 FORMAT(1X,'REINF.STEEL:',6(3X,D12.5),/)
      WRITE(3,74) (E(3,I),I=1,6)
   74 FORMAT(1X,'GIRDER MAT.:',6(3X,D12.5),/)
      WRITE(3,75) (E(4,I),I=1,6)
   75 FORMAT(1X,'DECK CONCR.:',6(3X,D12.5),/)
      WRITE(3,2222)
      WRITE(3,1300)
 1300 FORMAT(/,10X,'E L E M E N T   I N C I D E N C E   &   T Y P E')
      WRITE(3,1111)
      WRITE(3,1400)
 1400 FORMAT(1X,'ELEM #',8X,'N1',6X,'N2',4X,'TYPE',///)
      DO 20 I=1,NEL
      READ(1,*) IEL(I,1),IEL(I,2),IEL(I,3)
      ITYPE=IEL(I,3)
      WRITE(3,1500) I,IEL(I,1),IEL(I,2),ITYPE
 1500 FORMAT(2X,I5,6X,I3,5X,I3,5X,I3,/)
   20 CONTINUE
      WRITE(3,2222)
      DO 10 I=1,NNOD
      READ(1,*) X(I,1),X(I,2),IVAR(I,1),IVAR(I,2),IVAR(I,3)
   10 CONTINUE
      WRITE(3,1000)
 1000 FORMAT(/,10X,'N O D A L   C O O R D I N A T E S')
      WRITE(3,1111)
      WRITE(3,1100)
 1100 FORMAT(1X,'NODE #',6X,'X',15X,'Y',///)
      WRITE(3,1200) (I,X(I,1),X(I,2),I=1,NNOD)
 1200 FORMAT(4X,I3,4X,D12.5,4X,D12.5/)
      WRITE(3,2222)
C                     CONSTANT CROSS SECTION
      IF(ICONST.EQ.0) THEN
      READ(1,*) (CDIM(I),I=1,8)
      DO 2 I=1,NEL
      DO 3 J=1,8
      DIM(I,J)=CDIM(J)
    3 CONTINUE
      IF(IEL(I,3).EQ.1)THEN
      DIM(I,3)=CDIM(2)/2+CDIM(4)+CDIM(6)+CDIM(8)
      IF(IGMAT.EQ.0) DIM(I,3)=CDIM(2)/2+CDIM(4)
      DIM(I,4)=DIM(I,3)
      DIM(I,5)=0
      DIM(I,6)=0
      DIM(I,7)=0
      DIM(I,8)=0
      END IF
    2 CONTINUE
      ELSE
C                   VARIABLE CROSS SECTION
      DO 60 I=1,NEL
      READ(1,*) (DIM(I,J),J=1,8)
   60 CONTINUE
      END IF
      WRITE(3,30)
   30 FORMAT(20X,'S E C T I O N A L   D I M E N T I O N S',//)
      WRITE(3,1111)
C                          STEEL GIRDER
      IF(IGMAT.EQ.0) THEN
      WRITE(3,4)
    4 FORMAT(1X,'ELEM #',3X,'DECK WIDTH   ',2X,
     +                     'DECK THICK.   ',2X,
     +                     'GIRDER AREA   ',2X,
     +                     'GIRDER HEIGHT',2X,
     +                     'MOM. INERTIA ',//)
      DO 5 I=1,NEL
      IF(IEL(I,3).EQ.1)THEN
      WRITE(3,55) I,(DIM(I,J),J=1,4)
   55 FORMAT(4X,I3,2X,D13.6,2X,D13.6,5X,'H1=',D11.4,9X,'H2=',D11.4,/)
      ELSE
      WRITE(3,6) I,(DIM(I,J),J=1,5)
    6 FORMAT(4X,I3,5(2X,D13.6),/)
      END IF
    5 CONTINUE
C                 CONCRETE RECTANGULAR GIRDER
      ELSE
      IF(IATYPE.EQ.0)THEN
      WRITE(3,7)
    7 FORMAT(1X,'ELEM #',3X,'DECK WIDTH    ',2X,'DECK THICK.  ',
     +                     2X,'GIRDER WIDTH ',2X,'GIRDER HEIGHT',//)
      DO 8 I=1,NEL
      IF(IEL(I,3).EQ.1)THEN
      WRITE(3,55) I,(DIM(I,J),J=1,4)
      ELSE
      WRITE(3,29) I,(DIM(I,J),J=1,4)
   29 FORMAT(4X,I3,4(2X,D13.6),/)
      END IF
    8 CONTINUE
C                 CONCRETE T, I  OR  BOX GIRDER
      ELSE
      WRITE(3,100)
  100 FORMAT(1X,'ELEM #',3X,'DECK WIDTH    ',2X,'DECK THICK.  ',
     +                     2X,'TOP WIDTH     ',2X,'TOP THICK.   ',
     +                     2X,'WEB WIDTH     ',2X,'WEB THICK.   ',
     +                     2X,'BOTTOM WIDTH ',2X,'BOTTOM THICK.',//)
      DO 110 I=1,NEL
      IF(IEL(I,3).EQ.1) THEN
      WRITE(3,55) I,(DIM(I,J),J=1,4)
      ELSE
      WRITE(3,12) I,(DIM(I,J),J=1,8)
   12 FORMAT(4X,I3,8(2X,D13.6),/)
      END IF
  110 CONTINUE
      END IF
      END IF
      WRITE(3,2222)
      IF(ISTEEL.EQ.0) THEN
      READ(1,*) (STEEL(1,J),J=1,6)
      DO 48 I=2,NEL
      DO 49 J=1,6
      STEEL(I,J)=STEEL(1,J)
      IF(IEL(I,3).EQ.1.AND.J.GE.3) STEEL(I,J)=0
   49 CONTINUE
   48 CONTINUE
      ELSE
      DO 50 I=1,NEL
      READ(1,*) (STEEL(I,J),J=1,6)
   50 CONTINUE
      END IF
      WRITE(3,13)
   13 FORMAT(30X,'R E I N F.   S T E E L   C O N T E N T',/)
```

```
      WRITE(3,1111)
      WRITE(3,14)
   14 FORMAT(20X,'D E C K ',16X,'G I R D E R  T O P',8X,
     +           'G I R D E R  B O T T O M ')
      WRITE(3,1111)
      WRITE(3,15)
   15 FORMAT(1X,'ELEM #',6X,'AREA',8X,'DIST.TO BASE',
     +                   6X,'AREA',8X,'DIST.TO BASE',
     +                   6X,'AREA',8X,'DIST.TO BASE',//)
      DO 16 I=1,NEL
      WRITE(3,17) I,(STEEL(I,J),J=1,6)
   17 FORMAT(4X,I3,6(2X,D13.6),/)
   16 CONTINUE
      WRITE(3,2222)
      DO 200 I=1,NLOCA
      READ(1,*) (LOCA(I,J),J=1,8)
      IF(LOCA(I,1).EQ.2) LOCA(I,3)=1
  200 CONTINUE
      WRITE(3,210)
  210 FORMAT(15X,'L O A D   C A S E S ')
      WRITE(3,1111)
      WRITE(3,220)
  220 FORMAT(2X,'(1)',2X,'GIRDER DEAD LOAD',/,
     +        2X,'(2)',2X,'PRESTRESSING',/,
     +        2X,'(3)',2X,'DECK DEAD LOAD',/,
     +        2X,'(4)',2X,'SUPPORT DISPLACEMENT',/,
     +        2X,'(5)',2X,'LIVE LOAD',/,
     +        2X,'(6)',2X,'TEMPERATURE',/,
     +        2X,'(7)',2X,'CREEP, SHRINKAGE AND RELAXATION',///,
     +        8X,'EFFECT TABLE',//,
     +        8X,' 0  NONE',/,
     +        8X,' 1  CREEP',/,
     +        8X,' 2  SHRINKAGE',/,
     +        8X,' 3  RELAXATION',/,
     +        8X,' 4  ALL')
      WRITE(3,1111)
      WRITE(3,230)
  230 FORMAT(1X,'LOAD CASE #',3X,'TYPE',3X,'COMP.SECTION',
     +3X,'# STEPS',3X,'PRINT STEP',3X,'EFFECT',3X,'F. DAY',3X,
     +'L. DAY',3X,'HINGED',/)
      DO 240 I=1,NLOCA
      WRITE(3,250) I,(LOCA(I,J),J=1,8)
  250 FORMAT(10X,I2,4X,I2,9X,I1,11X,I2,11X,I1,9X,I1,7X,I4,5X,I4,
     +5X,I4,/)
  240 CONTINUE
      WRITE(3,1111)
      WRITE(3,260)
  260 FORMAT(1X,'P R E S C R I B E D   D I S P L A C E M E N T S',//,
     +        1X,'SUP #',2X,'NODE #',3X,'DISP.VALUE',/)
      DO 270 I=1,NSUP
      READ(1,*) (PREDIS(I,J),J=1,2)
      NN=PREDIS(I,1)
      WRITE(3,280) I,NN,PREDIS(I,2)
  280 FORMAT(4X,I2,5X,I3,3X,D10.3,/)
  270 CONTINUE
      WRITE(3,1111)
      READ(1,*) IT1,IT2,IT3
      WRITE(3,2000)
 2000 FORMAT(1X,'T E M P E R A T U R E   V A R I A T I O N  ( F )',//)
      WRITE(3,2001)
 2001 FORMAT(1X,'TOP DECK',5X,'TOP GIRDER',5X,'BOTTOM GIRDER',//)
      WRITE(3,2002) IT1,IT2,IT3
 2002 FORMAT(3X,I4,10X,I4,13X,I4)
      WRITE(3,2222)
      WRITE(3,1504)
 1504 FORMAT(30X,'L I V E   L O A D ')
      WRITE(3,2222)
      WRITE(3,1505)
 1505 FORMAT(/,10X,'N O D A L   A P P L I E D   L O A D S   (+)R,UP,CC')
      WRITE(3,1111)
      WRITE(3,1506)
 1506 FORMAT(1X,'NODE #',15X,'FX',16X,'FY',16X,'MZ',///)
      DO 21 I=1,NNOD
      READ(1,*) ALOAD(I,1),ALOAD(I,2),ALOAD(I,3)
      WRITE(3,1507) I,ALOAD(I,1),ALOAD(I,2),ALOAD(I,3)
 1507 FORMAT(4X,I3,8X,D15.8,5X,D15.8,5X,D15.8,/)
   21 CONTINUE
      WRITE(3,2222)
      WRITE(3,1510)
 1510 FORMAT(/,10X,'E L E M E N T   A P P L I E D   L O A D S   (+)DOWN')
      WRITE(3,1111)
      WRITE(3,1520)
 1520 FORMAT(1X,'ELEM #',11X,'U.DIST.',11X,'CONC.',15X,'FR.L.NODE',///)
      DO 25 I=1,NEL
      READ(1,*) APLOAD(I,1),APLOAD(I,2),APLOAD(I,3)
      WRITE(3,1530) I,APLOAD(I,1),APLOAD(I,2),APLOAD(I,3)
 1530 FORMAT(4X,I3,8X,D15.8,5X,D15.8,5X,D15.8,/)
   25 CONTINUE
      WRITE(3,2222)
      IF(DRIVLL.EQ.0) THEN
      WRITE(3,1535)
 1535 FORMAT(10X,'LOAD DRIVEN METHOD FOR L.L.',/)
      ELSE
      WRITE(3,1541)
 1541 FORMAT(10X,'DISPLACEMENT DRIVEN METHOD FOR L.L.',/)
      WRITE(3,1542) NODR,DRIVLL
 1542 FORMAT(10X,'NODE #',I3,5X,'AT',5X,D15.8,/)
      WRITE(3,1543) ALPLL
 1543 FORMAT(10X,'L.L UPPER LIMIT = ',D10.3,1X,'X',/)
      END IF
C                           PRESTRESSING
      DO 31 I=1,NNOD
      YCABLE(I)=0
   31 CONTINUE
      DO 32 I=1,NEL
      DO 33 J=1,7
      CABLE(I,J)=0
   33 CONTINUE
   32 CONTINUE
      IPRET=0
      NPS=1
      DO 36 I=1,10
      DO 37 J=1,5
      PSEGM(I,J)=0
   37 CONTINUE
   36 CONTINUE
      IF(IGMAT.EQ.1) THEN
      WRITE(3,2222)
      WRITE(3,1540)
 1540 FORMAT(30X,'P R E S T R E S S I N G')
```

```
      WRITE(3,2222)
      READ(1,*)IPRET,IPROF,NPS,FM,FK,IST
      WRITE(3,1570)
 1570 FORMAT(5X,'PRESTRESSING AREA AND INITIAL FORCE',/)
      IF(IPRET.EQ.0)THEN
      WRITE(3,1575)
 1575 FORMAT(/,15X,'( POS-TENSIONED CABLE )')
      IF(IST.EQ.0)THEN
      WRITE(3,1577)
 1577 FORMAT(/,15X,'( LOW-RELAXATION STEEL )')
      ELSE
      WRITE(3,1578)
 1578 FORMAT(/,15X,'( STRESS-RELIEVED STEEL )')
      END IF
      ELSE
      FM=0
      FK=0
      WRITE(3,1576)
 1576 FORMAT(/,15X,'( PRE-TENSIONED CABLE )')
      IF(IST.EQ.0)THEN
      WRITE(3,1577)
      ELSE
      WRITE(3,1578)
      END IF
      END IF
      WRITE(3,1111)
      WRITE(3,1580)
 1580 FORMAT(1X,'FROM ELEM #  TO  ELEM #',7X,'AREA',8X,
     +       'INITIAL FORCE',5X,'JACKING SIDE',//)
      DO 40 I=1,NPS
      READ(1,*)PSEGM(I,1),PSEGM(I,2),PSEGM(I,3),PSEGM(I,4),PSEGM(I,5)
      NE1=PSEGM(I,1)
      NE2=PSEGM(I,2)
      AO=PSEGM(I,3)
      FO=PSEGM(I,4)
      IPULL=PSEGM(I,5)
      WRITE(3,1590)NE1,NE2,AO,FO,IPULL
 1590 FORMAT(9X,I3,9X,I3,3X,D12.5,4X,D13.6,12X,I1,/)
   40 CONTINUE
      WRITE(3,2222)
      WRITE(3,1550)
 1550 FORMAT(10X,'C A B L E   P R O F I L E',//)
      IF(IPROF.EQ.0)THEN
      WRITE(3,1600)
 1600 FORMAT(15X,'( STRAIGHT )')
      END IF
      IF(IPROF.EQ.1)THEN
      WRITE(3,1601)
 1601 FORMAT(15X,'( PARABOLIC )')
      END IF
      IF(IPROF.EQ.2)THEN
      WRITE(3,1602)
 1602 FORMAT(15X,'( OTHER )')
      END IF
      WRITE(3,1111)
      WRITE(3,1555)
 1555 FORMAT(1X,'NODE #',3X,'DIST.TO BASE',//)
      IF(IPROF.LT.2)THEN
      DO 41 I=1,NPS
      READ(1,*)(PRF(I,J),J=1,6)
   41 CONTINUE
      CALL PROFIL(PRF,NPS,IPROF,NNOD,YCABLE,X)
      ELSE
      DO 35 I=1,NNOD
      READ(1,*)YCABLE(I)
   35 CONTINUE
      END IF
      DO 42 I=1,NNOD
      WRITE(3,1560)I,YCABLE(I)
 1560 FORMAT(4X,I3,3X,D12.5,/)
   42 CONTINUE
      END IF
      WRITE(3,2222)
      WRITE(3,1015)
 1015 FORMAT(/,50X,'   R E S U L T S  ',/)
      WRITE(3,2222)
      RETURN
      END
C*****************************************************************

      SUBROUTINE PROFIL(PRF,NPS,IPROF,NNOD,YCABLE,X)
C*****************************************************************
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION PRF(10,6),YCABLE(NNOD),X(NNOD,2)
      DO 10 I=1,NPS
      N1=PRF(I,1)
      N2=PRF(I,3)
      N3=PRF(I,5)
      X2=X(N2,1)-X(N1,1)
      X3=X(N3,1)-X(N1,1)
      Y1=PRF(I,2)
      Y2=PRF(I,4)
      Y3=PRF(I,6)
      IF(IPROF.EQ.1)THEN
      A=((Y3-Y2)-(Y2-Y1)*(X3/X2-1))/((X3**2-X2**2)-X2*(X3-X2))
      B=((Y2-Y1)/X2)-A*X2
      DO 20 J=N1,N3
      XN=X(J,1)-X(N1,1)
      YCABLE(J)=A*XN**2+B*XN+Y1
   20 CONTINUE
      ELSE
      DO 30 J=N1,N3
      XN=X(J,1)-X(N1,1)
      IF(XN.LE.X2)THEN
      YCABLE(J)=Y2+(Y1-Y2)*(X2-XN)/X2
      ELSE
      YCABLE(J)=Y2+(Y3-Y2)*(XN-X2)/(X3-X2)
      END IF
   30 CONTINUE
      END IF
   10 CONTINUE
      RETURN
      END
C*****************************************************************

      SUBROUTINE BAND(NEL,IEL,NBAND)
C*****************************************************************
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION IEL(NEL,4)
      INTEGER DIF,IDIF
```

```
      NBAND=0
      IDIF=0
      DO 10 I=1,NEL
      DIF=IEL(I,1)-IEL(I,2)
      IF(DIF.LT.0) DIF=-DIF
      IF(DIF.GT.IDIF)IDIF=DIF
   10 CONTINUE
      NBAND=3*IDIF+3
      WRITE(3,1010)NBAND
 1010 FORMAT(1X,'NBAND=',I5,/)
      RETURN
      END
C ***************************************************************

      SUBROUTINE GDISP(NNOD,NVAR,IVAR,NDISP)
C****************************************************************
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION NVAR(NNOD,3),IVAR(NNOD,3)
      NDISP=0
C
C         NVAR - STORES THE GLOBAL DISPLACEMENTS
C
      DO 11 I=1,NNOD
      DO 9 J=1,3
      NVARIJ=IVAR(I,J)
      IF(NVARIJ.EQ.0)THEN
      NDISP=NDISP+1
      NVAR(I,J)=NDISP
      ELSE
      NVAR(I,J)=0
      END IF
    9 CONTINUE
   11 CONTINUE
      WRITE(3,2222)
      WRITE(3,1600)
 1600 FORMAT(/,10X,'G L O B A L   D I S P L E C E M E N T  #')
      WRITE(3,1111)
 1111 FORMAT(/,130('-'),/)
      WRITE(3,1700)
 1700 FORMAT(1X,'NODE #',7X,'X',5X,'Y',3X,'THETA',///)
      WRITE(3,1800) (I,(NVAR(I,J),J=1,3),I=1,NNOD)
 1800 FORMAT(2X,I5,5X,I3,3X,I3,3X,I3,/)
      WRITE(3,2222)
 2222 FORMAT(/,130('*'),/)
      RETURN
      END
C****************************************************************

      SUBROUTINE CONSTR(IGMAT,IATYPE,NLOCA,GAMAG,GAMAD,
     * NNOD,NSUP,NEL,NCEL,NODE3,NDISP,NBAND,E,BC,NVAR,IVAR,
     *      IEL,X,ALOAD,D,APLOAD,REAC,DIM,STEEL,AREA,DELO,CLOAD,
     *          ELOAD,SDISP,LOCA,PREDIS,YCABLE,CABLE,IPRET,
     *                 NPS,PSEGM,FM,FK,ICONST,STA,STRB,STRST,CRACK,
     *     NGL,NL,NS1,NS2,NS3,NS4,EALL,Y,ICRACK,IALPHA,IELD,EPERM,
     * STRE,CNF,ICHECK,NSUP3,DISP,DCM,DCL,FORCE,STREL,STRLC,
     * AK12,KVAR,P1,DU,FINCAB,CABSST,GTP,RELIST,ST,NCHEL,NCH3,ISSC,
     *    DRIVLL,NODR,AK22,ALPLL,ITNST,IT1,IT2,IT3,T,IST)
C****************************************************************
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION E(4,6),NVAR(NNOD,3),IEL(NEL,3),X(NNOD,2),ALOAD(NNOD,3),
     *B(1),AFLOAD(NEL,3),REAC(NSUP,3),DIM(NEL,8),IVAR(NNOD,3)
     *,STEEL(NEL,6),AREA(NEL,8),DELO(NEL,2),ST(NODE3,NBAND)
     *        ,CLOAD(NNOD,3),ELOAD(NEL,3),SDISP(NNOD,3),DISP(NNOD,3)
     * ,LOCA(NLOCA,8),PREDIS(NSUP,2),YCABLE(NNOD),CABLE(NEL,7),
     *RELIST(300,10),PSEGM(10,5),ELONG(10,2),STA(NEL,NS1),STRB(NEL,8),
     * FINCAB(NEL,3),CABSST(NEL),STRST(NEL,NS2),CRACK(NEL,8),Y(NL,3),
     *GTP(NEL),ICRACK(NEL,NL),IALPHA(NEL,NL),EALL(NEL,NS3),STRLC(NEL,NL)
     *,EPERM(NEL,NL),STRE(NEL,NS3),IELD(NEL,NS4),CNF(NODE3,3),
     *ICHECK(NCHEL),DCM(300,NCH3),DCL(NNOD,3),STREL(NEL,NL),
     *FORCE(NEL,3),AK12(1),P1(1),DU(1),KVAR(NNOD,3),T(6)
C     VARIABLES :
C       MODIFY = MODIFY GLOBAL DISPL.
C       INVERT = INVERT SUPPORT DISPL.
C       INCLUD = INCLUDE CABLE STIFFNESS
C       NOWPRO = PRESTRESSING IS BEEING APPLIED
C       ICOUNT = POS-TENSIONING HAS BEEN APPLIED
C       IAFTER = PRESTRESSING HAS ALREADY BEEN APPLIED
C
      DO 50 I=1,NODE3
      DO 51 J=1,3
      CNF(I,J)=0
   51 CONTINUE
   50 CONTINUE
      DO 100 I=1,NNOD
      DO 200 J=1,3
      SDISP(I,J)=0
  200 CONTINUE
  100 CONTINUE
      DO 300 I=1,NEL
      FINCAB(I,1)=0
      FINCAB(I,2)=0
      FINCAB(I,3)=0
      CABSST(I)=0
      GTP(I)=0
      DO 410 K=1,NS1
      STA(I,K)=0
  410 CONTINUE
      DO 420 K=1,8
      STRB(I,K)=0
  420 CONTINUE
      DO 425 K=1,NS3
      STRE(I,K)=0
  425 CONTINUE
      DO 426 K=1,NS4
      IELD(I,K)=1
  426 CONTINUE
      DO 430 K=1,8
      CRACK(I,K)=0
  430 CONTINUE
      DO 440 K=1,NL
      ICRACK(I,K)=1
      IALPHA(I,K)=0
      EPERM(I,K)=0
      STEEL(I,K)=0
      STRLC(I,K)=0
  440 CONTINUE
  300 CONTINUE
      DO 301 I=1,NSUP
      DO 302 J=1,3
      REAC(I,J)=0
```

```
  302 CONTINUE
  301 CONTINUE
      DO 303 I=1,300
      DO 304 J=1,NCH3
      DCM(I,J)=0
  304 CONTINUE
      DO 305 K=1,10
      RELIST(I,K)=0
  305 CONTINUE
  303 CONTINUE
      CALL DELOAD(IGMAT,IATYPE,GAMAG,GAMAD,DIM,NEL,IEL,DELC)
      CALL SECAO(IGMAT,IATYPE,GAMAG,GAMAD,DIM,E,STEEL,NEL,
     *           IEL,AREA)
C
C                    GO TO ALL LOAD CASES
C
      LLCEL=0
      INCLUD=0
      ICOUNT=0
      IAFTER=0
      NOWPRO=0
      ITEST=0
      NTITER=0
      FINISH=0
      ICSTR=0
      SHEAL=1
      AK22=0
      DO 500 LC=1,NLOCA
C                                       LATE HINGED SUPPORT
      IF(LOCA(LC,8).EQ.1)BC=1.E30
      IF(LOCA(LC,1).EQ.-5) THEN
      LOCA(LC,1)=5
      LIVLO=-1
      ELSE
      LIVLO=1
      END IF
      ICOMP=LOCA(LC,2)
C                             UPDATE LATE CONNECTION ELEMENTS
C                             FOR LIVE LOAD CONTINUITY
      IF(NCEL.GT.0.AND.ICOMP.EQ.0)THEN
      DO 10 NE=1,NEL
      IF(IEL(NE,3).EQ.2)THEN
      IEL(NE,3)=1
      LLCEL=2
      END IF
   10 CONTINUE
      END IF
      IF(LLCEL.EQ.2.AND.ICOMP.EQ.1)THEN
      DO 20 NE=1,NEL
      IF(IEL(NE,3).EQ.1)IEL(NE,3)=0
   20 CONTINUE
      END IF
C                             UPDATE CURRENT TIME
      T(1)=LOCA(LC,6)
C                             UPDATE LOADING TIMES
      IF(LOCA(LC,1).LE.5)THEN
      IF(ICOMP.EQ.0)THEN
      T(4)=LOCA(LC,6)
      ELSE
      T(4)=LOCA(LC,6)
      T(5)=LOCA(LC,6)
      END IF
      END IF
C
      IF(NOWPRO.EQ.1)IAFTER=1
      NOWPRO=0
      IF(ICOUNT.EQ.1)INCLUD=1
      IF(LOCA(LC,1).GE.6)ICSTR=1
C                                       DECIDE WHICH LOAD CASE
      IF(LOCA(LC,1).EQ.1)GO TO 1
      IF(LOCA(LC,1).EQ.2)GO TO 2
      IF(LOCA(LC,1).EQ.3)GO TO 3
      IF(LOCA(LC,1).EQ.4)GO TO 4
      IF(LOCA(LC,1).EQ.5)GO TO 5
      IF(LOCA(LC,1).EQ.6)GO TO 6
      IF(LOCA(LC,1).EQ.7)GO TO 7
C                                       GIRDER DEAD LOAD
    1 DO 510 J=1,NEL
      DLOAD(J,1)=DELC(J,1)
      DLOAD(J,2)=0
      DLOAD(J,3)=0
  510 CONTINUE
      DO 511 J=1,NNOD
      DO 512 K=1,3
      CLOAD(J,K)=0
  512 CONTINUE
  511 CONTINUE
      GO TO 1000
C                                       PRESTRESSING
    2 DO 520 J=1,NNOD
      DO 521 K=1,3
      CLOAD(J,K)=0
  521 CONTINUE
  520 CONTINUE
      DO 522 J=1,NEL
      DO 523 K=1,3
      DLOAD(J,K)=0
  523 CONTINUE
  522 CONTINUE
      CALL PRCTEN(YCABLE,CLOAD,X,CABLE,IEL,NEL,NNOD,NOWPRO,
     * *          NPS,PSEGM,ELONG,PM,FK,E,FINCAD)
      IF(IFRET.EQ.0) ICOUNT=1
      IF(IFRET.EQ.1) INCLUD=1
      NOWPRO=1
      GO TO 1000
C                                       DECK DEAD LOAD
    3 DO 530 J=1,NEL
      DLOAD(J,1)=DELC(J,2)
      DLOAD(J,2)=0
      DLOAD(J,3)=0
  530 CONTINUE
      DO 531 J=1,NNOD
      DO 532 K=1,3
      CLOAD(J,K)=0
  532 CONTINUE
  531 CONTINUE
      GO TO 1000
C                                       SUPPORT DISPLACEMENT
C
    4 CALL SUPDIS(IGMAT,IATYPE,NLOCA,GAMAG,GAMAD,ICSTR,
```

```
     *          NNOD,NSUP,NEL,NODE3,NDISP,NBAND,E,BC,NVAR,IVAR,
     *       IEL,X,ALOAD,B,APLOAD,REAC,DIM,STEEL,AREA,DELC,
     *         SDISP,LOCA,PREDIS,YCABLE,CABLE,IPRET,
     *              NPS,PSEGM,FM,FK,ICONST,STA,STRB,STRST,CRACK,
     *    NGL,NL,NS1,NS2,NS3,NS4,EALL,Y,ICRACK,IALPHA,IELD,EPERM,
     *       STRE,CNP,ICHECK,NSUP3,DISPL,FORCE,STRLC,
     *      ITER,FINCAB,CABSST,GTP,ST,NCHEL,NCH3,ISSC,RELIST,SREAL,
     *FINISH,ITNST,INCLUD,NOWPRO,ICOUNT,IAFTER,NTITER,ICOMP,ELONG,LC,T)
      IF(FINISH.GT.0)GO TO 9000
      GO TO 500
C                              LIVE LOAD
    5 DO 550 J=1,NEL
      DO 551 K=1,3
      DLOAD(J,K)=APLOAD(J,K)*LIVLO
  551 CONTINUE
  550 CONTINUE
      DO 552 J=1,NNOD
      DO 553 K=1,3
      CLOAD(J,K)=ALOAD(J,K)*LIVLO
  553 CONTINUE
  552 CONTINUE
      IF(LOCA(LC,3).LT.1000)GO TO 1000
C
C                       DISPLACEMENT INCREMENT METHOD
C
      CALL DIMLL(IGMAT,IATYPE,NLOCA,GAMAG,GAMAD,ICSTR,
     *          NNOD,NSUP,NEL,NODE3,NDISP,NBAND,E,BC,NVAR,IVAR,
     *      IEL,X,ALOAD,B,APLOAD,REAC,DIM,STEEL,AREA,DELO,CLOAD,
     *         DLOAD,SDISP,LOCA,PREDIS,YCABLE,CABLE,IPRET,
     *              NPS,PSEGM,FM,FK,ICONST,STA,STRB,STRST,CRACK,
     *    NGL,NL,NS1,NS2,NS3,NS4,EALL,Y,ICRACK,IALPHA,IELD,EPERM,
     *       STRE,CNP,ICHECK,NSUP3,DISP,DCM,DCL,FORCE,STRLC,
     * AK12,KVAR,P1,DU,FINCAB,CABSST,GTP,ST,NCHEL,NCH3,ISSC,DRIVLL,
     *         NODR,AK22,ALPLL,ITER,RELIST,SREAL,
     *FINISH,ITNST,INCLUD,NOWPRO,ICOUNT,IAFTER,NTITER,ICOMP,ELONG,LC,T)
      IF(FINISH.GT.0)GO TO 9000
      GO TO 500
C                          LOAD INCREMENT METHOD
C
 1000 CALL LIM(IGMAT,IATYPE,NLOCA,GAMAG,GAMAD,ICSTR,
     *          NNOD,NSUP,NEL,NODE3,NDISP,NBAND,E,BC,NVAR,IVAR,
     *      IEL,X,ALOAD,APLOAD,REAC,DIM,STEEL,AREA,DELC,CLOAD,
     *         DLOAD,SDISP,B,LOCA,PREDIS,YCABLE,CABLE,IPRET,
     *              NPS,PSEGM,FM,FK,ICONST,STA,STRB,STRST,CRACK,
     *    NGL,NL,NS1,NS2,NS3,NS4,EALL,Y,ICRACK,IALPHA,IELD,EPERM,
     *       STRE,CNP,ICHECK,NSUP3,DISP,DCM,DCL,FORCE,STRLC,
     *      ITER,FINCAD,CABSST,GTP,ST,NCHEL,NCH3,ISSC,RELIST,SREAL,
     *FINISH,ITNST,INCLUD,NOWPRO,ICOUNT,IAFTER,NTITER,ICOMP,ELONG,LC,T)
      IF(FINISH.GT.0)GO TO 9000
      GO TO 500
C                               TEMPERATURE
C
    6 CALL TEMPER(IT1,IT2,IT3,IGMAT,IATYPE,NLOCA,GAMAG,GAMAD,ICSTR,
     *          NNOD,NSUP,NEL,NODE3,NDISP,NBAND,E,BC,NVAR,IVAR,
     *      IEL,X,ALOAD,APLOAD,REAC,DIM,STEEL,AREA,DELC,CLOAD,
     *         DLOAD,SDISP,B,LOCA,PREDIS,YCABLE,CABLE,IPRET,
     *              NPS,PSEGM,FM,FK,ICONST,STA,STRB,STRST,CRACK,
     *    NGL,NL,NS1,NS2,NS3,NS4,EALL,Y,ICRACK,IALPHA,IELD,EPERM,
     *       STRE,CNP,ICHECK,NSUP3,DISP,DCM,DCL,FORCE,STRLC,
     *      ITER,FINCAB,CABSST,GTP,ST,NCHEL,NCH3,ISSC,RELIST,SREAL,
     *FINISH,ITNST,INCLUD,NOWPRO,ICOUNT,IAFTER,NTITER,ICOMP,ELONG,LC,T)
      IF(FINISH.GT.0)GO TO 9000
      GO TO 500
C                     CREEP, SHRINKAGE AND RELAXATION
C
    7 CALL TIMEF(IGMAT,IATYPE,NLOCA,GAMAG,GAMAD,ICSTR,
     *          NNOD,NSUP,NEL,NODE3,NDISP,NBAND,E,BC,NVAR,IVAR,
     *      IEL,X,ALOAD,APLOAD,REAC,DIM,STEEL,AREA,DELC,CLOAD,
     *         DLOAD,SDISP,B,LOCA,PREDIS,YCABLE,CABLE,IPRET,
     *              NPS,PSEGM,FM,FK,ICONST,STA,STRB,STRST,CRACK,
     *    NGL,NL,NS1,NS2,NS3,NS4,EALL,Y,ICRACK,IALPHA,IELD,EPERM,
     * STRE,CNP,ICHECK,NSUP3,DISP,DCM,DCL,FORCE,STREL,STRLC,
     *      ITER,FINCAB,CABSST,GTP,ST,NCHEL,NCH3,ISSC,RELIST,SREAL,
     *FINISH,ITNST,INCLUD,NOWPRO,ICOUNT,IAFTER,NTITER,ICOMP,ELONG,LC,
     *T,IST)
      IF(FINISH.GT.0)GO TO 9000
      GO TO 500
  500 CONTINUE
 9000 IF(NCHEL.GT.0) THEN
      CALL PLIST(NCHEL,ICHECK,ITNST,DCM,FINISH,NCH3,ITER)
      END IF
      CALL RECLST(RELIST,ITNST,NDISP,NNOD,PREDIS,NSUP,NVAR)
      RETURN
      END
C************************************************************

      SUBROUTINE SUPDIS(IGMAT,IATYPE,NLOCA,GAMAG,GAMAD,ICSTR,
     *          NNOD,NSUP,NEL,NODE3,NDISP,NBAND,E,BC,NVAR,IVAR,
     *      IEL,X,ALOAD,B,APLOAD,REAC,DIM,STEEL,AREA,DELO,
     *         SDISP,LOCA,PREDIS,YCABLE,CABLE,IPRET,
     *              NPS,PSEGM,FM,FK,ICONST,STA,STRB,STRST,CRACK,
     *    NGL,NL,NS1,NS2,NS3,NS4,EALL,Y,ICRACK,IALPHA,IELD,EPERM,
     *       STRE,CNP,ICHECK,NSUP3,DISP,DCM,DCL,FORCE,STRLC,
     *      ITER,FINCAB,CABSST,GTP,ST,NCHEL,NCH3,ISSC,RELIST,SREAL,
     *FINISH,ITNST,INCLUD,NOWPRO,ICOUNT,IAFTER,NTITER,ICOMP,ELONG,LC,T)
C************************************************************
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION E(4,6),NVAR(NNOD,3),IEL(NEL,3),X(NNOD,2),ALOAD(NNOD,3),
     *B(1),APLOAD(NEL,3),REAC(NSUP,3),DIM(NEL,8),IVAR(NNOD,3)
     *          ,STEEL(NEL,6),AREA(NEL,6),DELO(NEL,2),ST(NODE3,NBAND)
     *,SDISP(NNOD,3),DISP(NNOD,3),STRLC(NEL,NL)
     *          ,LOCA(NLOCA,8),PREDIS(NSUP,2),YCABLE(NNOD),CABLE(NEL,7)
     *             ,PSEGM(10,5),ELONG(10,2),STA(NEL,NS1),STRB(NEL,8),
     *FINCAB(NEL,3),CABSST(NEL),STRST(NEL,NS2),CRACK(NEL,8),Y(NL,3),
     *          GTP(NEL),ICRACK(NEL,NL),IALPHA(NEL,NL),EALL(NEL,NS3),
     *      EPERM(NEL,NL),STRE(NEL,NS3),IELD(NEL,NS4),CNP(NODE3,3),
     *        ICHECK(NCHEL),DCM(300,NCH3),DCL(NNOD,3),
     *FORCE(NEL,3),RELIST(300,10),T(6)
C
      MODIFY=0
      CALL MODGD(NNOD,NSUP,NVAR,IVAR,NDISP,PREDIS,MODIFY)
C
      DO 10 J=1,NODE3
      CNP(J,3)=0
   10 CONTINUE
C
      NSTEPS=LOCA(LC,3)
      DO 2010 J=1,NSUP
      PREDIS(J,2)=PREDIS(J,2)/NSTEPS
 2010 CONTINUE
```

```
C
      DO 3000 ISTEP=1,NSTEPS
      ITNST=ITNST+1
      ND=0
      DO 20 J=1,NNOD
      DO 30 K=1,3
      ND=ND+1
      B(ND)=0
      DISP(J,K)=0
   30 CONTINUE
   20 CONTINUE
      CALL NWAREA(NEL,DIM,ICOMP,IATYPE,IGMAT,IEL,NGL,NL,STRE,ICRACK,
     +             EALL,STEEL,NS3,Y,AREA,E,FINISH)
      IF(FINISH.EQ.7)GO TO 5000
      CALL ADSTIF(NNOD,NDISP,NBAND,NEL,IEL,NVAR,X,ST,BC,DIM,AREA,
     +             YCABLE,CABLE,INCLUD,NSUP3,NSUP,PREDIS)
      CALL NEWSOL(ST,B,NDISP,NBAND,NVAR,NNOD,NSUP,PREDIS)
      CALL SOLVE(NDISP,NBAND,ST,B)
      CALL DISPLA(B,NDISP,NVAR,NNOD,DISP,SDISP)
      CALL STRAIN(B,DIM,NEL,STEEL,IEL,NVAR,IGMAT,IATYPE,IPRET,NNOD,
     +X,ICOMP,STA,STRB,STRST,NGL,NDL,NL,NS1,NS2,Y,GTP,NOWPRO)
      DO 5555 NE=1,NEL
      DO 5556 L=1,NL
      STRLC(NE,L)=STRLC(NE,L)+STRST(NE,L)
 5556 CONTINUE
 5555 CONTINUE
      IF(IGMAT.EQ.1.AND.INCLUD.EQ.1)THEN
      NWSTP=1
      CALL MODCAB(CABLE,YCABLE,B,NEL,IEL,NVAR,X,NNOD,E,CABSST,
     +             NWSTP,NODE3)
      END IF
      CALL ECLBRM(CNF,NEL,FORCE,STRST,NS2,EALL,NS3,IPRET,ICSTR,
     +             Y,NL,NGL,DIM,ICOMP,IATYPE,IGMAT,IEL,ICRACK,
     + STRE,AREA,STEEL,ISTOP,DCL,B,X,NNOD,STRLC,LC,LOCA,NLOCA,
     +             NVAR,E,NDL,IELD,NS4,EPERM,STA,NS1,NDISP,NBAND,
     +      ST,DISP,SDISP,STRB,ITER,NTITER,ISSC,NODE3,ISTEP,FINISH,
     +INCLUD,CABLE,FINCAB,YCABLE,CABSST,GTP,NOWPRO,NSTEPS,T,SREAL,BC)
      IF(FINISH.GT.0)GO TO 5000
      IF(IGMAT.EQ.0)THEN
      IF(ICOMP.EQ.0)GO TO 1235
      END IF
      ERG=E(3,3)
      IF(IGMAT.EQ.0)ERG=E(3,6)
      ERD=E(4,3)
      CALL CRACKS(STRB,DIM,NEL,IGMAT,CRACK,ERG,ERD,ICOMP,X,IEL,NNOD,
     +             ICRACK,NGL,NL)
      CALL ACRACK(NEL,AREA,STA,NS1,NS3,EALL,DIM,IATYPE,IGMAT,NGL,NL,
     +             IEL,ICOMP,ICRACK,IALPHA,ERG,ERD,Y,ICSTR)
 1235 CONTINUE
      CALL REACT(NSUP,NNOD,NVAR,REAC,PREDIS,ITNST,RELIST,DCL)
      IF(ISTEP.LT.NSTEPS)THEN
      IF(LOCA(LC,4).EQ.0)GO TO 2900
      END IF
 5000 CALL OUTPUT(NEL,ICOMP,AREA,NNOD,NVAR,FORCE,SDISP,IGMAT,CABLE,
     +        NOWPRO,FM,FK,NPS,PSEGM,ELONG,ICHECK,NCHEL,IATYPE,DIM,
     +             NGL,NL,STA,NS1,STRE,NS3,EALL,STRB,ERG,ERD,CRACK,
     +             ICRACK,IALPHA,IELD,NS4,IEL,Y,NSUP,NSUP3,REAC,PREDIS
     +             ,DISP,ISTEP,LC,NSTEPS,ITER,NTITER)
 2900 IF(NCHEL.GT.0)THEN
      STEP=ISTEP
      STEPS=NSTEPS
      SALPHA=STEP/STEPS
      TIME=T(1)
      CALL MOCURV(DCM,NCH3,NCHEL,NEL,FORCE,SDISP,NNOD,STRB,
     +             ITNST,ICHECK,DIM,IGMAT,IEL,ITER,SALPHA,TIME)
      END IF
      IF(FINISH.GT.0)GO TO 6000
 3000 CONTINUE
      MODIFY=1
      CALL MODGD(NNOD,NSUP,NVAR,IVAR,NDISP,PREDIS,MODIFY)
      DO 2500 J=1,NSUP
      PREDIS(J,2)=-NSTEPS*PREDIS(J,2)
 2500 CONTINUE
 6000 RETURN
      END
C**************************************************************

      SUBROUTINE DIMII(IGMAT,IATYPE,NLOCA,GAMAG,GAMAD,ICSTR,
     +               NNOD,NSUP,NEL,NODE3,NDISP,NBAND,E,BC,NVAR,IVAR,
     +        IEL,X,ALOAD,B,APLOAD,REAC,DIM,STEEL,AREA,DELC,CLOAD,
     +             DLOAD,SDISP,LOCA,PREDIS,YCABLE,CABLE,IPRET,
     +                 NPS,PSEGM,FM,FK,ICONST,STA,STRB,STRST,CRACK,
     +    NGL,NL,NS1,NS2,NS3,NS4,EALL,Y,ICRACK,IALPHA,IELD,EPERM,
     +        STRE,CNF,ICHECK,NSUP3,DISP,DCM,DCL,FORCE,STRLC,
     + AK12,KVAR,P1,DU,FINCAB,CABSST,GTP,ST,NCHEL,NCH3,ISSC,DRIVLL,
     +   NODR,AK22,ALPLL,ITER,RELIST,SREAL,
     +FINISH,ITNST,INCLUD,NOWPRO,ICOUNT,IAFTER,NTITER,ICOMP,ELONG,LC,T)
C***************************************************************
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION E(4,6),NVAR(NNOD,3),IEL(NEL,3),X(NNOD,2),ALOAD(NNOD,3),
     +B(1),APLOAD(NEL,3),REAC(NSUP,3),DIM(NEL,9),IVAR(NNOD,3)
     +          ,STEEL(NEL,6),AREA(NEL,8),DELC(NEL,2),ST(NODE3,NBAND)
     +        ,CLOAD(NNOD,3),DLOAD(NEL,3),SDISP(NNOD,3),DISP(NNOD,3)
     +   ,LOCA(NLOCA,8),PREDIS(NSUP,2),YCABLE(NNOD),CABLE(NEL,7),
     +RELIST(300,10),PSEGM(10,5),ELONG(10,2),STA(NEL,NS1),STRB(NEL,8),
     +FINCAB(NEL,3),CABSST(NEL),STRST(NEL,NS2),CRACK(NEL,8),Y(NL,3),
     +          GTP(NEL),ICRACK(NEL,NL),IALPHA(NEL,NL),EALL(NEL,NS3),
     +  EPERM(NEL,NL),STRE(NEL,NS3),IELD(NEL,NS4),CNF(NODE3,3),
     +ICHECK(NCHEL),DCM(300,NCH3),DCL(NNOD,3),STRLC(NEL,NL),
     +FORCE(NEL,3),AK12(1),P1(1),DU(1),KVAR(NNOD,3),T(6)
      ISTEP=0
      NEXST=0
      ALPHA=0
      SALPHA=0
      SALOLD=0
C                 OBTAIN NEW GLOBAL DISPLACEMENTS ( KVAR )
      NNDISP=0
      IVAR(NODR,2)=1
      DO 7011 J=1,NNOD
      DO 7009 K=1,3
      IF(IVAR(J,K).EQ.0)THEN
      NNDISP=NNDISP+1
      KVAR(J,K)=NNDISP
      ELSE
      KVAR(J,K)=0
      END IF
 7009 CONTINUE
 7011 CONTINUE
C
      CALL EQLOAD(NNOD,NEL,IEL,DLOAD,CLOAD,X,P1,KVAR)
```

```
C
C             STORE THE EXTERNAL LOAD VECTOR
C
      ND=0
      DO 7003 J=1,NNOD
      DO 7004 K=1,3
      IF(NVAR(J,K).NE.0) THEN
      ND=ND+1
      CNF(ND,3)=CLOAD(J,K)
      END IF
 7004 CONTINUE
 7003 CONTINUE
C
C                     BEGIN NEW STEP
 7005 ITER=0
      NWSTP=1
      ISTEP=ISTEP+1
      ITNST=ITNST+1
      DENOM=0
      P2=CLOAD(NCDB,2)
      ND=0
      DO 7001 J=1,NNOD
      DO 7002 K=1,3
      DISP(J,K)=0
      IF(KVAR(J,K).NE.0) THEN
      ND=ND+1
      P1(ND)=CLOAD(J,K)
      END IF
 7002 CONTINUE
 7001 CONTINUE
      CALL NWAREA(NEL,DIM,ICOMP,IATYPE,IGMAT,IEL,NGL,NL,STRE,
     +             ICRACK,EALL,STEEL,NS3,Y,AREA,E,FINISH)
      IF(FINISH.EQ.7)GO TO 7099
      CALL ADSTIF(NNOD,NDISP,NBAND,NEL,IEL,NVAR,X,ST,BC,DIM,
     +             AREA,YCABLE,CABLE,INCLUD,NSUPJ,NSUP,
     +             PREDIS)
      CALL SPLIT(NBAND,NVAR,NODR,NDISP,ST,NNOD,AK12,AK22)
      CALL NWSTIF(NNOD,NNDISP,NBAND,NEL,IEL,KVAR,X,ST,BC,DIM,
     +             AREA,YCABLE,CABLE,INCLUD,NODR)
      CALL SOLVE(NNDISP,NBAND,ST,P1)
      DO 7010 J=1,NNDISP
      DU(J)=-AK12(J)*DRIVLL
 7010 CONTINUE
C                                   ITERATIONS LOOP
 7015 CONTINUE
      CALL RESOLV(NNDISP,NBAND,ST,DU)
      CALL FRACTN(NWSTP,AK12,DU,P2,P1,NNDISP,DENOM,ALPHA,SALPHA,
     +             AK22,DRIVLL)
      JUMP=NVAR(NODR,2)
      DO 7020 J=1,NDISP
      IF(J.LT.JUMP)THEN
      SMALL=DSQRT(DABS(ALPHA))*DSQRT(DABS(P1(J)))
      IF(SMALL.LT.1.E-38)THEN
      B(J)=DU(J)
      ELSE
      B(J)=ALPHA*P1(J)+DU(J)
      END IF
      END IF
      IF(J.EQ.JUMP)B(J)=DRIVLL*NWSTP
      IF(J.GT.JUMP)THEN
      SMALL=DSQRT(DABS(ALPHA))*DSQRT(DABS(P1(J-1)))
      IF(SMALL.LT.1.E-38)THEN
      B(J)=DU(J-1)
      ELSE
      B(J)=ALPHA*P1(J-1)+DU(J-1)
      END IF
      END IF
 7020 CONTINUE
      CALL DISPLA(B,NDISP,NVAR,ENCD,DISP,SDISP)
      CALL STRAIN(B,DIM,NEL,STEEL,IEL,NVAR,IGMAT,IATYPE,IPRET,NNOD,
     +X,ICOMP,STA,STRB,STRST,NGL,NDL,NL,NS1,NS2,Y,GTP,NOWPRO)
      DO 5555 NE=1,NEL
      DO 5556 L=1,NL
      STRLC(NE,L)=STRLC(NE,L)+STRST(NE,L)
 5556 CONTINUE
 5555 CONTINUE
      IF(IGMAT.EQ.1) THEN
      IF(IAFTER.EQ.1)THEN
      CALL MODCAB(CABLE,YCABLE,B,NEL,IEL,NVAR,X,NNOD,E,CABSST,NWSTP,
     +             NODE3)
      END IF
      END IF
C
C             EXTERNAL LOAD LINEAR ADJUST
C
      DO 7021 J=1,NODE3
      CNF(J,2)=CNF(J,1)+SALPHA*CNF(J,3)
 7021 CONTINUE
C
      CALL STRESS(E,STRE,NEL,NS3,IELE,NS4,EPERM,NL,STA,STRST,ICSTR,
     +SREAL,NS1,NS2,EALL,IGMAT,NGL,STEEL,ICCMP,ICRACK,IEL,ISSC,
     +FINISH,NWSTP,T)
      CALL FORSCT(NEL,FORCE,NS1,EALL,NS3,Y,NL,NGL,DIM,ICCMP,
     +             IATYPE,IGMAT,IEL,ICRACK,STRE,AREA,STEEL,STA,
     +             INCLUD,FINCAB,CABLE,YCABLE,NNOD,GTP,NOWPRO)
      IF(FINISH.GT.0)GO TO 7050
      CALL CHEKEQ(FORCE,CNF,NEL,ISTOP,IEL,BCL,DIM,B,AREA,
     +             X,NNOD,NVAR,NODE3,NDISP,FINCAB,INCLUD,BC)
      IF(ISTOP.EQ.1) THEN
      NEXST=0
      GO TO 7050
      END IF
      DO 7040 J=1,NDISP
      IF(J.LT.JUMP)DU(J)=B(J)
      IF(J.EQ.JUMP)P2=B(J)
      IF(J.GT.JUMP)DU(J-1)=B(J)
 7040 CONTINUE
      NWSTP=0
      ITER=ITER+1
      NTITER=NTITER+1
      IF(ITER.GE.500)FINISH=1
C                            INCRASE STEP
C     IF(ITER.GE.50) THEN
C     NEXST=NEXST+1
C     IF(NEXST.GE.6) THEN
C     FINISH=6
C     GO TO 7050
C     ELSE
C     DRIVLL=1.2*DRIVLL
C     GO TO 7005
```

```
C     END IF
C     END IF
C
      GO TO 7015
C
 7050 IF(IGMAT.EQ.0) THEN
      IF(ICOMP.EQ.0) GO TO 1236
      END IF
      ERG=E(3,3)
      IF(IGMAT.EQ.0) ERG=E(3,6)
      ERD=E(4,3)
      CALL CRACKS(STRB,DIM,NEL,IGMAT,CRACK,ERG,ERD,ICOMP,X,IEL,NNOD,
     +            ICRACK,NGL,NL)
      CALL ACRACK(NEL,AREA,STA,NS1,NS3,EALL,DIM,IATYPE,IGMAT,NGL,NL,
     +            IEL,ICOMP,ICRACK,IALPHA,ERG,ERD,Y,ICSTR)
 1236 CONTINUE
      DO 7051 J=1,NNOD
      DO 7052 K=1,3
      JA=NVAR(J,K)
      IF(JA.NE.0) B(JA)=DISP(J,K)
 7052 CONTINUE
 7051 CONTINUE
      CALL REACT(NSUP,NNOD,NVAR,REAC,PREDIS,ITNST,RELIST,DCL)
      NSTEPS=LOCA(LC,3)
      IF(SALPHA.GE.ALPLL)FINISH=2
C                                    CHECK LOAD INCREMENT
C     IF(NWSTP.EQ.0) THEN
C     IF(SALOLD.GT.0) THEN
C     IF(SALPHA/SALOLD.GT.1) THEN
C     IF(SALPHA/SALOLD.LT.1.0001)FINISH=5
C     END IF
C     END IF
C     END IF
C     SALOLD=SALPHA
      IF(FINISH.GT.0)GO TO 7099
      IF(LOCA(LC,4).EQ.0)GO TO 7100
 7099 CALL OUTPUT(NEL,ICOMP,AREA,NNOD,NVAR,FORCE,SDISP,IGMAT,
     +            CABLE,NOWPRO,FM,FK,NFS,PSEGM,ELONG,ICHECK,NCHEL,
     +            IATYPE,DIM,NGL,NL,STA,NS1,STRE,NS3,EALL,STRB,ERG,
     +            ERD,CRACK,ICRACK,IALPHA,IELD,NS4,IEL,Y,NSUP,NSUP3,
     +            REAC,PREDIS,DISP,ISTEP,LC,NSTEPS,ITER,NTITER)
 7100 IF(NCHEL.GT.0) THEN
      TIME=T(1)
      CALL MOCURV(DCM,NCH3,NCHEL,NEL,FORCE,SDISP,NNOD,STRB,ITNST,
     +            ICHECK,DIM,IGMAT,IEL,ITER,SALPHA,TIME)
      END IF
      IF(FINISH.EQ.0)GO TO 7005
C                              UPDATE THE EXTERNAL LOAD VECTOR
      DO 1000 K=1,NODE3
      CNF(K,1)=CNF(K,1)+CNF(K,3)*SALPHA
 1000 CONTINUE
C
      RETURN
      END
C*********************************************************************

      SUBROUTINE LIN(IGMAT,IATYPE,NLOCA,GAMAG,GAMAD,ICSTR,
     +            NNOD,NSUP,NEL,NODE3,NDISP,NBAND,E,BC,NVAR,IVAR,
     +        IEL,X,ALOAD,APLOAD,REAC,DIM,STEEL,AREA,DELO,CLOAD,
     +           DLOAD,SDISP,B,LOCA,PREDIS,YCABLE,CABLE,IPRET,
     +                 NPS,PSEGM,FM,FK,ICONST,STA,STRB,STRST,CRACK,
     +     NGL,NL,NS1,NS2,NS3,NS4,EALL,Y,ICRACK,IALPHA,IELD,EPERM,
     +       STRE,CNF,ICHECK,NSUP3,DISP,DCM,DCL,FORCE,STRLC,
     +      ITER,FINCAB,CABSST,GTP,ST,NCHEL,NCH3,ISSC,RELIST,SREAL,
     +FINISH,ITNST,INCLUD,NOWPRO,ICOUNT,IAFTER,NTITER,ICOMP,ELONG,LC,T)
C*********************************************************************
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION E(4,6),NVAR(NNOD,3),IEL(NEL,3),X(NNOD,2),ALOAD(NNOD,3),
     +B(1),APLOAD(NEL,3),REAC(NSUP,3),DIM(NEL,8),IVAR(NNOD,3)
     +          ,STEEL(NEL,6),AREA(NEL,6),DELO(NEL,2),ST(NODE3,NBAND)
     +        ,CLOAD(NNOD,3),DLOAD(NEL,3),SDISP(NNOD,3),DISP(NNOD,3)
     +        ,LOCA(NLOCA,8),PREDIS(NSUP,2),YCABLE(NNOD),CABLE(NEL,7)
     +              ,PSEGM(10,5),ELONG(10,2),STA(NEL,NS1),STRB(NEL,8),
     +FINCAB(NEL,3),CABSST(NEL),STRST(NEL,NS2),CRACK(NEL,8),Y(NL,3),
     +        GTP(NEL),ICRACK(NEL,NL),IALPHA(NEL,NL),EALL(NEL,NS3),
     +     EPERM(NEL,NL),STRE(NEL,NS3),IELD(NEL,NS4),CNF(NODE3,3),
     +          ICHECK(NCHEL),DCM(300,NCH3),DCL(NNOD,3),
     +FORCE(NEL,3),RELIST(300,10),T(6),STRLC(NEL,NL)
      NSTEPS=LOCA(LC,3)
C
      CALL EQLOAD(NNOD,NEL,IEL,DLOAD,CLOAD,X,B,NVAR)
C
C           STORE THE EXTERNAL LOAD VECTOR
C
      LVEC=1
      IF(NOWPRO.EQ.1.AND.IPRET.EQ.1) LVEC=0
      ND=0
      DO 7003 J=1,NNOD
      DO 7004 K=1,3
      IF(NVAR(J,K).NE.0) THEN
      ND=ND+1
      CNF(ND,3)=CLOAD(J,K)*LVEC
      END IF
 7004 CONTINUE
 7003 CONTINUE
C
      DO 5000 ISTEP=1,NSTEPS
      ITNST=ITNST+1
      ND=0
      DO 5010 L=1,NNOD
      DO 5020 M=1,3
      DISP(L,M)=0
      IF(NVAR(L,M).NE.0) THEN
      ND=ND+1
      B(ND)=CLOAD(L,M)/NSTEPS
      END IF
 5020 CONTINUE
 5010 CONTINUE
      CALL ANALIS(IGMAT,IATYPE,NLOCA,GAMAG,GAMAD,ISTEP,NSTEPS,ICSTR,
     +            NNOD,NSUP,NEL,NODE3,NDISP,NBAND,E,BC,NVAR,IVAR,
     +        IEL,X,ALOAD,APLOAD,REAC,DIM,STEEL,AREA,DELO,CLOAD,
     +           DLOAD,SDISP,B,LOCA,PREDIS,YCABLE,CABLE,IPRET,
     +                 NPS,PSEGM,FM,FK,ICONST,STA,STRB,STRST,CRACK,
     +     NGL,NL,NS1,NS2,NS3,NS4,EALL,Y,ICRACK,IALPHA,IELD,EPERM,
     +       STRE,CNF,ICHECK,NSUP3,DISP,DCM,DCL,FORCE,STRLC,
     +      ITER,FINCAB,CABSST,GTP,ST,NCHEL,NCH3,ISSC,RELIST,SREAL,
     +FINISH,ITNST,INCLUD,NOWPRO,ICOUNT,IAFTER,NTITER,ICOMP,ELONG,LC,T)
      IF(FINISH.GT.0)GO TO 5001
 5000 CONTINUE
C
```

```
C                 UPDATE THE EXTERNAL LOAD VECTOR
C
      IF(NCWPRO.NE.1) THEN
      DO 6000 J=1,NODE3
      CNF(J,1)=CNF(J,1)+CNF(J,3)
 6000 CONTINUE
      END IF
C
 5001 RETURN
      END
C*****************************************************************
      SUBROUTINE ANALIS(IGMAT,IATYPE,NLOCA,GAMAG,GAMAD,ISTEP,NSTEPS,
     +        ICSTR,NNOD,NSUP,NEL,NODE3,NDISP,NBAND,E,BC,NVAR,IVAR,
     +          IEL,X,ALOAD,APLOAD,REAC,DIM,STEEL,AREA,DELC,CLOAD,
     +              DLOAD,SDISP,B,LCCA,PREDIS,YCABLE,CABLE,IPRET,
     +                     NPS,PSEGM,FM,FK,ICONST,STA,STRB,STRST,CRACK,
     +       NGL,NL,NS1,NS2,NS3,NS4,EALL,Y,ICRACK,IALPHA,IELD,EPERM,
     +         STRE,CNF,ICHECK,NSUP3,DISP,DCM,DCL,FORCE,STRLC,
     +       ITER,FINCAB,CABSST,GTP,ST,NCHEL,NCH3,ISSC,RELIST,SREAL,
     +FINISH,ITNST,INCLUD,NOWPRC,ICOUNT,IAFTER,NTITER,ICOMP,ELONG,LC,T)
C*****************************************************************
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION E(4,6),NVAR(NNOD,3),IEL(NEL,3),X(NNOD,2),ALOAD(NNOD,3),
     +B(1),APLOAD(NEL,3),REAC(NSUP,3),DIM(NEL,8),IVAR(NNOD,3)
     +          ,STEEL(NEL,6),AREA(NEL,8),DELO(NEL,2),ST(NODE3,NBAND)
     +        ,CLOAD(NNOD,3),DLOAD(NEL,3),SDISP(NNOD,3),DISP(NNOD,3)
     +        ,LOCA(NLOCA,8),PREDIS(NSUP,2),YCABLE(NNOD),CABLE(NEL,7)
     +              ,PSEGM(10,5),ELONG(10,2),STA(NEL,NS1),STRB(NEL,8),
     +FINCAB(NEL,3),CABSST(NEL),STRST(NEL,NS2),CRACK(NEL,8),Y(NL,3),
     +       GTP(NEL),ICRACK(NEL,NL),IALPHA(NEL,NL),EALL(NEL,NS3),
     +    EPERM(NEL,NL),STRE(NEL,NS3),IELD(NEL,NS4),CNF(NODE3,3),
     +        ICHECK(NCHEL),DCM(300,NCH3),DCL(NNOD,3),
     +FORCE(NEL,3),RELIST(300,10),T(6),STRLC(NEL,NL)
      CALL NWAREA(NEL,DIM,ICOMP,IATYPE,IGMAT,IEL,NGL,NL,STRE,ICRACK,
     +            EALL,STEEL,NS3,Y,AREA,E,FINISH)
      IF(FINISH.EQ.7)GO TO 4800
      CALL ASTIF(NNOD,NDISP,NBAND,NEL,IEL,NVAR,X,ST,BC,DIM,AREA,
     +            YCABLE,CABLE,INCLUD,NSUP3,NSUP,PREDIS)
      CALL SOLVE(NDISP,NBAND,ST,B)
      CALL DISPLA(B,NDISP,NVAR,NNOD,DISP,SDISP)
      CALL STRAIN(B,DIM,NEL,STEEL,IEL,NVAR,IGMAT,IATYPE,IPRET,NNOD,
     + X,ICOMP,STA,STRB,STRST,NGL,NDL,NL,NS1,NS2,Y,GTP,NCWPRO)
      IF(LOCA(LC,1).NE.7)THEN
      DO 5555 NE=1,NEL
      DO 5556 L=1,NL
      STRLC(NE,L)=STRLC(NE,L)+STRST(NE,L)
 5556 CONTINUE
 5555 CONTINUE
      END IF
      IF(IGMAT.EQ.1) THEN
      IF(INCLUD.EQ.1) THEN
      NWSTP=1
      CALL MODCAB(CABLE,YCABLE,B,NEL,IEL,NVAR,X,NNOD,E,CABSST,
     +            NWSTP,NODE3)
      IF(NCWPRO.EQ.1.AND.IPRET.EQ.1) THEN
      DO 8000 JK=1,NEL
      FINCAB(JK,1)=CABLE(JK,3)
 8000 CONTINUE
      END IF
      END IF
      END IF
      CALL EQLDRM(CNF,NEL,FORCE,STRST,NS2,EALL,NS3,IPRET,ICSTR,
     +            Y,NL,NGL,DIM,ICOMP,IATYPE,IGMAT,IEL,ICRACK,
     + STRE,AREA,STEEL,ISTOP,DCL,B,X,NNOD,STRLC,LC,LOCA,NLOCA,
     +            NVAR,E,NDL,IELD,NS4,EPERM,STA,NS1,NDISP,NBAND,
     +     ST,DISP,SDISP,STRB,ITER,NTITER,ISSC,NODE3,ISTEP,FINISH,
     +INCLUD,CABLE,FINCAB,YCABLE,CABSST,GTP,NOWPRC,NSTEPS,T,SREAL,BC)
      IF(FINISH.GT.0)GO TO 4800
      IF(IGMAT.EQ.0) THEN
      IF(ICOMP.EQ.0) GO TO 1234
      END IF
      ERG=E(3,3)
      IF(IGMAT.EQ.0) ERG=E(3,6)
      ERD=E(4,3)
      CALL CRACKS(STRB,DIM,NEL,IGMAT,CRACK,ERG,ERD,ICOMP,X,IEL,NNOD,
     +            ICRACK,NGL,NL)
      CALL ACRACK(NEL,AREA,STA,NS1,NS3,EALL,DIM,IATYPE,IGMAT,NGL,NL,
     +            IEL,ICOMP,ICRACK,IALPHA,ERG,ERD,Y,ICSTR)
 1234 CONTINUE
      CALL REACT(NSUP,NNOD,NVAR,REAC,PREDIS,ITNST,RELIST,DCL)
      IF(ISTEP.LT.NSTEPS)THEN
      IF(LOCA(LC,4).EQ.0)GO TO 4900
      END IF
 4800 CALL OUTPUT(NEL,ICOMP,AREA,NNOD,NVAR,FORCE,SDISP,IGMAT,CABLE,
     +       NOWPRO,FM,FK,NPS,PSEGM,ELONG,ICHECK,NCHEL,IATYPE,DIM,
     +            NGL,NL,STA,NS1,STRE,NS3,EALL,STRB,ERG,ERD,CRACK,
     +            ICRACK,IALPHA,IELD,NS4,IEL,Y,NSUP,NSUP3,REAC,PREDIS,
     +            DISP,ISTEP,LC,NSTEPS,ITER,NTITER)
 4900 IF(NCHEL.GT.0) THEN
      STEP=ISTEP
      STEPS=NSTEPS
      SALPHA=STEP/STEPS
      TIME=T(1)
      CALL MCCURV(DCM,NCH3,NCHEL,NEL,FORCE,SDISP,NNOD,STRB,
     +            ITNST,ICHECK,DIM,IGMAT,IEL,ITER,SALPHA,TIME)
      END IF
      RETURN
     *END
C*****************************************************************
      SUBROUTINE TEMPER(IT1,IT2,IT3,IGMAT,IATYPE,NLOCA,GAMAG,GAMAD,
     +        ICSTR,NNOD,NSUP,NEL,NODE3,NDISP,NBAND,E,BC,NVAR,IVAR,
     +          IEL,X,ALOAD,APLOAD,REAC,DIM,STEEL,AREA,DELC,CLOAD,
     +              DLOAD,SDISP,B,LCCA,PREDIS,YCABLE,CABLE,IPRET,
     +                     NPS,PSEGM,FM,FK,ICONST,STA,STRB,STRST,CRACK,
     +       NGL,NL,NS1,NS2,NS3,NS4,EALL,Y,ICRACK,IALPHA,IELD,EPERM,
     +         STRE,CNF,ICHECK,NSUP3,DISP,DCM,DCL,FORCE,STRLC,
     +       ITER,FINCAB,CABSST,GTP,ST,NCHEL,NCH3,ISSC,RELIST,SREAL,
     +FINISH,ITNST,INCLUD,NOWPRO,ICOUNT,IAFTER,NTITER,ICOMP,ELONG,LC,T)
C*****************************************************************
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION E(4,6),NVAR(NNOD,3),IEL(NEL,3),X(NNOD,2),ALOAD(NNOD,3),
     +B(1),APLOAD(NEL,3),REAC(NSUP,3),DIM(NEL,8),IVAR(NNOD,3)
     +          ,STEEL(NEL,6),AREA(NEL,8),DELO(NEL,2),ST(NODE3,NBAND)
     +        ,CLOAD(NNOD,3),DLOAD(NEL,3),SDISP(NNOD,3),DISP(NNOD,3)
     +        ,LOCA(NLOCA,8),PREDIS(NSUP,2),YCABLE(NNOD),CABLE(NEL,7)
     +              ,PSEGM(10,5),ELONG(10,2),STA(NEL,NS1),STRB(NEL,8),
     +FINCAB(NEL,3),CABSST(NEL),STRST(NEL,NS2),CRACK(NEL,8),Y(NL,3),
     +       GTP(NEL),ICRACK(NEL,NL),IALPHA(NEL,NL),EALL(NEL,NS3),
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     +    EPERM(NEL,NL),STRE(NEL,NS3),IELD(NEL,NS4),CNF(NODE3,3),
     +ICHECK(NCHEL),DCM(300,NCH3),DCL(NNOD,3),STRLC(NEL,NL),
     +FORCE(NEL,3),RELIST(300,10),T(6)
C                                 COEFFICIENTS OF THERMAL EXPANSION
      AS=0.0000065
      AC=0.0000055
C
      NSTEPS=LOCA(LC,3)
      IT1=IT1/NSTEPS
      IT2=IT2/NSTEPS
      IT3=IT3/NSTEPS
      DO 10 K=1,NODE3
      CNF(K,3)=0
   10 CONTINUE
C                                 INCREMENT STEPS
      DO 20 ISTEP=1,NSTEPS
      ITNST=ITNST+1
      DO 30 J=1,NNOD
      DO 40 K=1,3
      DISP(J,K)=0
   40 CONTINUE
   30 CONTINUE
C                                 OBTAIN TEMPERATURE STRAINS
      CALL TEMPST(NEL,NGL,NL,DIM,ICOMP,IATYPE,IGMAT,Y,IEL,IT1,IT2,
     +    IT3,NNOD,AC,AS,STRST,STEEL,INCLUD,YCABLE,CABLE,NS2,CABSST)
C
C                                 ADD THE TOTAL STRAINS
      DO 50 NE=1,NEL
      DO 60 K=1,NS2
      STA(NE,K)=STA(NE,K)+STRST(NE,K)
   60 CONTINUE
   50 CONTINUE
C                                 OBTAIN TEMPERATURE STRESSES
      NWSTP=0
      SREAL=0
      CALL STRESS(E,STRE,NEL,NS3,IELD,NS4,EPERM,NL,STA,STRST,
     +            ICSTR,SREAL,NS1,NS2,EALL,
     +IGMAT,NGL,STEEL,ICOMP,ICRACK,IEL,ISSC,FINISH,NWSTP,T)
      SREAL=1
C
C                                 TAKE OFF FROM TOTAL STRAINS
      DO 70 NE=1,NEL
      DO 80 K=1,NS2
      STA(NE,K)=STA(NE,K)-STRST(NE,K)
      STRST(NE,K)=-STRST(NE,K)
   80 CONTINUE
   70 CONTINUE
C                                 OBTAIN THE LOAD VECTOR
C
      CALL LVECTR(DCL,NEL,STRST,NS2,EALL,NS3,Y,NL,NGL,DIM,ICOMP,
     +            IATYPE,IGMAT,IEL,ICRACK,STRE,AREA,STEEL,INCLUD,
     +            CABSST,CABLE,YCABLE,NNCD,NOWPRO,X,NVAR,B)
C
C                                 PROCEED ANALYSIS
C
      CALL ANALIS(IGMAT,IATYPE,NLCCA,GAMAG,GAMAD,ISTEP,NSTEPS,ICSTR,
     +             NNOD,NSUP,NEL,NODE3,NDISP,NBAND,E,DC,NVAR,IVAR,
     +        IEL,X,ALOAD,APLOAD,REAC,DIM,STEEL,AREA,DELC,CLOAD,
     +          DLOAD,SDISP,B,LCCA,PREDIS,YCABLE,CABLE,IPRET,
     +               NPS,PSEGM,PM,PK,ICONST,STA,STRB,STRST,CRACK,
     +       NGL,NL,NS1,NS2,NS3,NS4,EALL,Y,ICRACK,IALPHA,IELD,EPERM,
     +         STRE,CNF,ICHECK,NSUP3,DISP,DCM,DCL,FORCE,STRLC,
     +        ITER,FINCAD,CABSST,JTP,ST,NCHEL,NCH3,ISSC,RELIST,SREAL,
     +FINISH,ITNST,INCLUD,NOWPRO,ICOUNT,IAFTER,NTITER,ICCMP,ELONG,LC,T)
      IF(FINISH.GT.0)GO TO 100
   20 CONTINUE
  100 RETURN
      END
C****************************************************************
```

```
      SUBROUTINE TEMPST(NEL,NGL,NL,DIM,ICOMP,IATYPE,IGMAT,Y,IEL,
     +                  IT1,IT2,IT3,NNCD,AC,AS,STRST,STEEL,INCLUD,
     +                  YCABLE,CABLE,NS2,CABSST)
C****************************************************************
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION DIM(NEL,8),Y(NL,3),IEL(NEL,3),STRST(NEL,NS2),
     +          STEEL(NEL,6),YCABLE(NNCD),CABLE(NEL,7),CABSST(NEL)
      DO 50 NE=1,NEL
      CABSST(NE)=0
      DO 55 K=1,NS2
      STRST(NE,K)=0
   55 CONTINUE
      ITYPE=IEL(NE,3)
      IF(ITYPE.EQ.1.AND.ICOMP.EQ.0)GC TO 50
      CALL LAYER(DIM,ICOMP,IATYPE,IGMAT,ITYPE,NEL,NE,Y,TH,NGL,NL)
      IF(ITYPE.EQ.1)THEN
      TH=(DIM(NE,3)+DIM(NE,4)-DIM(NE,2))/2
      GO TC 100
      END IF
C                                 GIRDER
      DO 60 L=1,NGL
      X=Y(L,1)
      ALPHA=AC
      IF(IGMAT.EQ.0)ALPHA=AS
      STRST(NE,L)=-ALPHA*(IT3+(IT2-IT3)*X/TH)
   60 CONTINUE
C                                 G. REINF.
      IF(IGMAT.EQ.0)GO TC 100
      IF(STEEL(NE,3).GT.0)THEN
      X=STEEL(NE,4)
      STRST(NE,NL+2)=-AS*(IT3+(IT2-IT3)*X/TH)
      END IF
      IF(STEEL(NE,5).GT.0)THEN
      X=STEEL(NE,6)
      STRST(NE,NL+3)=-AS*(IT3+(IT2-IT3)*X/TH)
      END IF
  100 IF(ICOMP.EQ.0)GO TO 200
C                                 D. REINF.
      IF(STEEL(NE,1).GT.0)THEN
      X=STEEL(NE,2)
      DT=DIM(NE,2)
      STRST(NE,NL+1)=-AS*(IT2+(IT1-IT2)*(X-TH)/DT)
      END IF
C                                 DECK
      LIM=NGL+1
      DO 70 L=LIM,NL
      X=Y(L,1)-TH
      IF(ITYPE.EQ.1)X=Y(L,1)
      DT=DIM(NE,2)
      STRST(NE,L)=-AC*(IT2+(IT1-IT2)*X/TH)
```

```
   70 CONTINUE
C                                          CABLE
  200 IF(INCLUD.EQ.1.AND.ITYPE.EQ.0) THEN
      N1=IEL(NE,1)
      N2=IEL(NE,2)
      X=(YCABLE(N1)+YCABLE(N2))/2
      STRAIN=-AS*(IT3+(IT2-IT3)*X/TH)
      CABSST(NE)=-STRAIN
      STRESS=CABLE(NE,7)*STRAIN
      CABLE(NE,5)=CABLE(NE,5)+STRESS
      END IF
   50 CONTINUE
      RETURN
      END
C**************************************************************

      SUBROUTINE TIMEF(IGMAT,IATYPE,NLCCA,GAMAG,GAMAD,ICSTR,
     +               NNOD,NSUP,NEL,NODE3,NDISP,NBAND,E,BC,NVAR,IVAR,
     +          IEL,X,ALOAD,APLOAD,REAC,DIM,STEEL,AREA,DELC,CLOAD,
     +             DLOAD,SDISP,B,LCCA,PREDIS,YCABLE,CABLE,IPRET,
     +                   NPS,PSEGM,FM,FK,ICONST,STA,STRB,STRST,CRACK,
     +       NGL,NL,NS1,NS2,NS3,NS4,EALL,Y,ICRACK,IALPHA,IELD,EPERM,
     + STRE,CNF,ICHECK,NSUP3,DISP,DCM,DCL,FORCE,STREL,STRLC,
     +ITER,PINCAB,CABSST,GTP,ST,NCHEL,NCH3,ISSC,RELIST,SREAL,FINISH,
     +ITNST,INCLUD,NONPRO,ICOUNT,IAFTER,NTITER,ICOMP,ELONG,LC,T,IST)
C**************************************************************
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION E(4,6),NVAR(NNOD,3),IEL(NEL,3),X(NNOD,2),ALOAD(NNOD,3),
     +B(1),APLOAD(NEL,3),REAC(NSUP,3),DIM(NEL,8),IVAR(NNOD,3)
     +            ,STEEL(NEL,6),AREA(NEL,8),DELO(NEL,2),ST(NODE3,NBAND)
     +        ,CLOAD(NNOD,3),DLOAD(NEL,3),SDISP(NNOD,3),DISF(NNOD,3)
     +        ,LOCA(NLOCA,8),PREDIS(NSUP,2),YCABLE(NNOD),CABLE(NEL,7)
     +              ,PSEGM(10,5),ELONG(10,2),STA(NEL,NS1),STRB(NEL,8),
     +PINCAB(NEL,3),CABSST(NEL),STRST(NEL,NS2),CRACK(NEL,8),Y(NL,3),
     +        GTP(NEL),ICRACK(NEL,NL),IALPHA(NEL,NL),EALL(NEL,NS3),
     +     EPERM(NEL,NL),STRE(NEL,NS3),IELD(NEL,NS4),CNF(NODE3,3),
     +         ICHECK(NCHEL),DCM(300,NCH3),DCL(NNOD,3),
     +FORCE(NEL,3),RELIST(300,10),T(6),STREL(NEL,NL),STRLC(NEL,NL)
      EL=LOCA(LC,5)
      NSTEPS=LOCA(LC,3)
      DO 10 I=1,NODE3
      CNF(I,3)=0
   10 CONTINUE
C                                 STEP CALCULATION
      FS=1./24
      DT=LOCA(LC,7)-LOCA(LC,6)
      RT=(DT/FS)**(1./(NSTEPS-1))
C                                      INCREMENT STEPS
      DO 20 ISTEP=1,NSTEPS
      ITNST=ITNST+1
      DO 30 J=1,NNOD
      DO 40 K=1,3
      DISP(J,K)=0
   40 CONTINUE
   30 CONTINUE
C                                          CALCULATE TIMES
      IF(ISTEP.EQ.1) THEN
      TSI=LOCA(LC,6)
      TSF=TSI+FS
      END IF
      IF(ISTEP.EQ.2) THEN
      TSI=LOCA(LC,6)+FS
      TSF=LOCA(LC,6)+FS*RT
      END IF
      IF(ISTEP.GE.3) THEN
      TSI=LOCA(LC,6)+FS*RT**(ISTEP-2)
      TSF=LOCA(LC,6)+FS*RT**(ISTEP-1)
      END IF
C                                        UPDATE CURRENT TIME
      T(1)=TSF
C
      DO 45 NE=1,NEL
      CABSST(NE)=0
      DO 46 K=1,NS2
      STRST(NE,K)=0
   46 CONTINUE
   45 CONTINUE
C                                         GO TO EFFECT LABLED
      IF(EL.EQ.1.OR.EL.EQ.4) THEN
      CALL CREEP(TSI,TSF,T,IGMAT,ICOMP,NEL,NGL,NL,IEL,STRST,
     +              NS2,STREL,STRLC)
      END IF
      IF(EL.EQ.2.OR.EL.EQ.4) THEN
      CALL SHRINK(TSI,TSF,T,IGMAT,ICOMP,NEL,NGL,NL,IEL,STRST,NS2)
      END IF
      IF(ISTEP.GT.1) THEN
      IF(EL.GE.3.AND.INCLUD.EQ.1) THEN
      CALL RELAX(IST,TSI,TSF,T,E,IEL,NEL,CABLE,CABSST,PINCAB)
      END IF
      END IF
      IF(EL.NE.3) THEN
C
C                                      ADD THE TOTAL STRAINS
      DO 50 NE=1,NEL
      DO 60 K=1,NS2
      STA(NE,K)=STA(NE,K)+STRST(NE,K)
   60 CONTINUE
   50 CONTINUE
C                                      OBTAIN EFFECT STRESSES
      NWSTP=0
      SREAL=0
      CALL STRESS(E,STRE,NEL,NS3,IELD,NS4,EPERM,NL,STA,STRST,
     +              ICSTR,SREAL,NS1,NS2,EALL,
     +IGMAT,NGL,STEEL,ICOMP,ICRACK,IEL,ISSC,FINISH,NWSTP,T)
      SREAL=1
C
C                                      TAKE OFF FROM TOTAL STRAINS
      DO 70 NE=1,NEL
      DO 80 K=1,NS2
      STA(NE,K)=STA(NE,K)-STRST(NE,K)
      STRST(NE,K)=-STRST(NE,K)
   80 CONTINUE
   70 CONTINUE
      END IF
C                                      OBTAIN THE LOAD VECTOR
C
      CALL LVECTR(DCL,NEL,STRST,NS2,EALL,NS3,Y,NL,NGL,DIM,ICOMP,
     +              IATYPE,IGMAT,IEL,ICRACK,STRE,AREA,STEEL,INCLUD,
     +              CABSST,CABLE,YCABLE,NNOD,NOMP3C,X,NVAR,B)
C
```

```
C                                 PROCEED ANALYSIS
C
      CALL ANALIS(IGMAT,IATYPE,NLOCA,GAMAG,GAMAD,ISTEP,NSTEPS,ICSTR,
     *            NNOD,NSUP,NEL,NODE3,NDISP,NBAND,E,BC,NVAR,IVAR,
     *       IEL,X,ALOAD,APLOAD,REAC,DIM,STEEL,AREA,DELC,CLOAD,
     *          DLOAD,SDISP,B,LCCA,PREDIS,YCABLE,CABLE,IPRET,
     *                NPS,PSEGM,FM,FK,ICONST,STA,STRB,STRST,CRACK,
     *     NGL,NL,NS1,NS2,NS3,NS4,CALL,Y,ICRACK,IALPHA,IELD,EPERM,
     *STRE,CNF,ICHECK,NSUP3,DISP,DCM,DCL,FORCE,STRLC,
     *      ITER,FINCAB,CABSST,GTP,ST,NCHEL,NCH3,ISSC,RELIST,SREAL,
     *FINISH,ITNST,INCLUD,NOWPRO,ICOUNT,IAFTER,NTITER,ICCMP,ELONG,LC,T)
      IF(FINISH.GT.0)GO TO 100
   20 CONTINUE
      DO 200 NE=1,NEL
      DO 201 L=1,NL
      STREL(NE,L)=STREL(NE,L)+STRLC(NE,L)
      STRLC(NE,L)=0
  201 CONTINUE
  200 CONTINUE
  100 RETURN
      END
C*****************************************************************

      SUBROUTINE CREEP(TSI,TSF,T,IGMAT,ICOMP,NEL,NGL,NL,IEL,
     *                 STRST,NS2,STREL,STRLC)
C*****************************************************************
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION T(6),STRST(NEL,NS2),IEL(NEL,3)
     *          ,STREL(NEL,NL),STRLC(NEL,NL)
C
C                                 ASSUMED CREEP CONSTANTS
      C=0.60
      D=10.0
      CUG=2.35
      CUD=2.35
C
      TFLG=T(4)
      TFLD=T(5)
      GCC=0
      DCC=0
C                                 GIRDER CREEP COEFFICIENT
      IF(IGMAT.NE.0)THEN
      IF(TSI.GT.TFLG)THEN
      DT=(TSI-TFLG)**C
      CTSI=(CUG*DT)/(D+DT)
      ELSE
      CTSI=0
      END IF
      DT=(TSF-TFLG)**C
      CTSF=(CUG*DT)/(D+DT)
      GCC=CTSF-CTSI
      END IF
C                                 DECK CREEP COEFFICIENT
      IF(ICOMP.EQ.1)THEN
      IF(TSI.GT.TFLD)THEN
      DT=(TSI-TFLD)**C
      CTSI=(CUD*DT)/(D+DT)
      ELSE
      CTSI=0
      END IF
      DT=(TSF-TFLD)**C
      CTSF=(CUD*DT)/(D+DT)
      DCC=CTSF-CTSI
      END IF
C
      DO 50 NE=1,NEL
      ITYPE=IEL(NE,3)
      IF(ITYPE.EQ.1.AND.ICOMP.EQ.0)GO TO 50
      LIMI=1
      IF(IGMAT.EQ.0.OR.ITYPE.EQ.1)LIMI=NGL+1
      LIMF=NL
      IF(ICOMP.EQ.0)LIMF=NGL
      DO 60 L=LIMI,LIMF
      CC=GCC
      IF(L.GT.NGL)CC=DCC
      REC=STREL(NE,L)*STRLC(NE,L)
      IRECOV=1
      IF(REC.GE.0)IRECOV=0
      STRAIN=STREL(NE,L)+STRLC(NE,L)
      STRST(NE,L)=-CC*(STRAIN+IRECOV*STRLC(NE,L))
   60 CONTINUE
   50 CONTINUE
      RETURN
      END
C*****************************************************************

      SUBROUTINE SHRINK(TSI,TSF,T,IGMAT,ICOMP,NEL,NGL,NL,
     *                  IEL,STRST,NS2)
C*****************************************************************
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION T(6),STRST(NEL,NS2),IEL(NEL,3)
C
C                                 ASSUMED SHRINKAGE COEFFICIENTS
      E=1
      F=45
      ESUG=0.000800
      ESUD=0.000800
C
      TGC=T(2)
      TDC=T(3)
C                                 GIRDER SHRINKAGE STRAIN
      IF(IGMAT.NE.0)THEN
      DT=TSI-TGC
      STSI=(ESUG*DT)/(F+DT)
      DT=TSF-TGC
      STSF=(ESUG*DT)/(F+DT)
      GSS=STSF-STSI
      END IF
C                                 DECK SHRINKAGE STRAIN
      IF(ICOMP.EQ.1)THEN
      DT=TSI-TDC
      STSI=(ESUD*DT)/(F+DT)
      DT=TSF-TDC
      STSF=(ESUD*DT)/(F+DT)
      DSS=STSF-STSI
      END IF
C
      DO 50 NE=1,NEL
      ITYPE=IEL(NE,3)
      IF(ITYPE.EQ.1.AND.ICOMP.EQ.0)GO TO 50
```

```
      IF(IGMAT.NE.0) THEN
      DO 60 L=1,NGL
      STRST(NE,L)=STRST(NE,L)+DSS
   60 CONTINUE
      END IF
      IF(ICOMP.EQ.1) THEN
      LIN=NGL+1
      DO 70 L=LIN,NL
      STRST(NE,L)=STRST(NE,L)+DSS
   70 CONTINUE
      END IF
   50 CONTINUE
      RETURN
      END
C*****************************************************************

      SUBROUTINE RELAX(IST,TSI,TSF,T,E,IEL,NEL,CABLE,CABSST,FINCAB)
C*****************************************************************
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION T(6),E(4,6),IEL(NEL,3),CABLE(NEL,7),CABSST(NEL),
     *          FINCAB(NEL,3)
C
C                           ASSUMED CONSTANTS
      IF(IST.EQ.0) THEN
C                      LOW-RELAXATION STEEL
      A=45
      B=0.9
      ELSE
C                      STRESS-RELIEVED STEEL
      A=10
      B=0.85
      END IF
C
      TP=T(6)
      RT=DLOG10((TSF-TP)/(TSI-TP))
      FPU=E(1,5)+E(1,3)*(E(1,6)-(E(1,4)/E(1,1))-(E(1,5)-E(1,4))/E(1,2))
C
      DO 50 NE=1,NEL
      IF(IEL(NE,3).EQ.1.OR.CABLE(NE,4).EQ.0)GO TO 50
      FST=FINCAB(NE,1)/CABLE(NE,4)
      RELX=(FST*RT/A)*(FST/(B*FPU)-0.55)
      CABLE(NE,5)=CABLE(NE,5)-RELX
      CABSST(NE)=RELX/CABLE(NE,7)
   50 CONTINUE
      RETURN
      END
C*****************************************************************

      SUBROUTINE PLIST(NCHEL,ICHECK,ITNST,DCM,FINISH,NCH3,ITER)
C*****************************************************************
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION ICHECK(NCHEL),DCM(300,NCH3)
      WRITE(3,6000)
 6000 FORMAT(10X,'M O M E N T - C U R V A T U R E - ',
     *       'D E F L E C T I O N')
      WRITE(3,1111)
      DO 6010 NK=1,NCHEL
      NEC=ICHECK(NK)
      WRITE(3,6020) NEC
 6020 FORMAT(20X,'ELEMENT #',2X,I3)
      WRITE(3,1111)
      WRITE(3,6030)
 6030 FORMAT(1X,'STEP #',5X,'MOMENT',6X,'CURVATURE',3X,'DEFLECTION',
     *        3X,'LOAD FRCTN',3X,'CURT. TIME',3X,'ITERATIONS',//)
      DO 6040 I=1,ITNST
      LIMI=NK*6-5
      LIMF=NK*6-1
      ITERA=DCM(I,NK*6)
      WRITE(3,6050)I,(DCM(I,J),J=LIMI,LIMF),ITERA
 6050 FORMAT(4X,I3,5(3X,D10.3),6X,I3,/)
 6040 CONTINUE
      IF(FINISH.EQ.1)THEN
      WRITE(3,6051)ITER
 6051 FORMAT(10X,'**** ',I3,' ITERATIONS EXCEEDED IN ONE STEP ****')
      END IF
      IF(FINISH.EQ.3)THEN
      WRITE(3,6052)
 6052 FORMAT(10X,'*** R.STEEL OR STEEL GIRDER RUPTURE ***')
      END IF
      IF(FINISH.EQ.2)THEN
      WRITE(3,6053)
 6053 FORMAT(10X,'*** LIVE LOAD UPPER LIMIT HAS BEEN REACHED ***')
      END IF
      IF(FINISH.EQ.4)THEN
      WRITE(3,6054)
 6054 FORMAT(10X,'*** CONCRETE ULTIMATE STRAIN HAS BEEN REACHED ***')
      END IF
      IF(FINISH.EQ.5)THEN
      WRITE(3,6055)
 6055 FORMAT(10X,'*** LOAD INCREMENT IS LESS THEN 0.01/100 ***')
      END IF
      IF(FINISH.EQ.6)THEN
      WRITE(3,6056)
 6056 FORMAT(10X,'*** DRIVING DISPL. HAS BEEN INCREASED FIVE TIMES ***')
      END IF
      IF(FINISH.EQ.7)THEN
      WRITE(3,6057)
 6057 FORMAT(10X,'*** SECTION IS ALL CRACKED OR YIELDED ***')
      END IF
      WRITE(3,1111)
 1111 FORMAT(/,130('-'),/)
 6010 CONTINUE
      RETURN
      END
C*****************************************************************

      SUBROUTINE RECL (RELIST,ITNST,NDISP,NNOD,PREDIS,NSUP,NVAR)
C*****************************************************************
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION RELIST(300,10),PREDIS(NSUP,2),NVAR(NNOD,3),NUM(20)
      NRT=NNOD*3-NDISP
      WRITE(3,2222)
 2222 FORMAT(/,130('*'),/)
      WRITE(3,1000)
 1000 FORMAT(30X,'S U P P O R T   R E A C T I O N S')
      WRITE(3,1111)
 1111 FORMAT(/,130 ('-'),/)
      DO 5 I=1,20
      NUM(I)=0
    5 CONTINUE
```

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      J=0
      DO 10 NS=1,NSUP
      NN=PREDIS(NS,1)
      DO 20 I=1,3
      IF(NVAR(NN,I).EQ.0)THEN
      J=J+1
      NUM(J)=NS
      J=J+1
      NUM(J)=I
      END IF
   20 CONTINUE
   10 CONTINUE
      NRT2=NRT*2
      WRITE(3,1100) (NUM(I),I=1,NRT2)
 1100 FORMAT(1X,'STEP',10(2X,'S#',I2,1X,'R#',I2),///)
      DO 30 I=1,ITNST
      WRITE(3,1200)I,(RELIST(I,J),J=1,NRT)
 1200 FORMAT(I4,1X,10(1X,D10.3),/)
   30 CONTINUE
      RETURN
      END
C*****************************************************************

      SUBROUTINE PLOT(XX,YY,DCM,ITNST,NCH3,ICHECK,NCHEL)
C*****************************************************************
      IMPLICIT REAL*8(A-H,O-Z)
      REAL*4 XX(ITNST),YY(ITNST)
      DIMENSION DCM(300,NCH3),ICHECK(NCHEL)
      ITERM=0
      DO 1 I=1,ITNST
      XX(I)=0
      YY(I)=0
    1 CONTINUE
      WRITE(3,2222)
 2222 FORMAT(/,130('*'),/)
      WRITE(3,10)
   10 FORMAT(50X,'P L O T S')
      DO 20 I=1,NCHEL
      WRITE(3,2222)
      DO 30 J=1,ITNST
      K=(I-1)*5
      XX(J)=DCM(J,K+2)
      YY(J)=DCM(J,K+1)
   30 CONTINUE
      CALL GENPT(XX,YY,ITNST,ITERM)
      NEC=ICHECK(I)
      WRITE(3,100)NEC
  100 FORMAT(50X,'ELEM #',I4,5X,'M O M E N T - C U R V A T U R E',//)
      DO 40 J=1,ITNST
      K=(I-1)*5
      XX(J)=-DCM(J,K+3)
   40 CONTINUE
      CALL GENPT(XX,YY,ITNST,ITERM)
      WRITE(3,110)NEC
  110 FORMAT(50X,'ELEM #',I4,5X,'M O M E N T - D E F L E C T I O N',//)
   20 CONTINUE
      RETURN
      END
C*****************************************************************
      SUBROUTINE EQLBRM(CNF,NEL,FORCE,STRST,NS2,EALL,NS3,IPRET,ICSTR,
     +              Y,NL,NGL,DIM,ICOMP,IATYPE,IGMAT,IEL,ICRACK,
     +  STRE,AREA,STEEL,ISTOP,DCL,B,X,NNOD,STRLC,LC,LOCA,NLOCA,
     +              NVAR,E,NDL,IELD,NS4,EPERM,STA,NS1,NDISP,NBAND,
     +       ST,DISP,SDISP,STRB,ITER,NTITER,ISSC,NODE3,ISTEP,FINISH,
     + INCLUD,CABLE,FINCAB,YCABLE,CABSST,GTP,NOWPRO,NSTEPS,T,SREAL,BQ
C****************************************************************
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION FORCE(NEL,3),STRST(NEL,NS2),EALL(NEL,NS3),
     +             Y(NL,3),DIM(NEL,8),IEL(NEL,3),ICRACK(NEL,NL),
     +             STRE(NEL,NS3),AREA(NEL,8),STEEL(NEL,6),DCL(NNOD,3),
     +B(1),X(NNOD,2),NVAR(NNOD,3),E(4,6),STRLC(NEL,NL),LOCA(NLOCA,8),
     +   IELD(NEL,NS4),EPERM(NEL,NL),STA(NEL,NS1),GTP(NEL),T(6),
     +             ST(NODE3,NBAND),DISP(NNOD,3),SDISP(NNOD,3),STRB(NEL,8)
     +,FINCAB(NEL,3),CABSST(NEL),CABLE(NEL,7),YCABLE(NNOD),CNF(NODE3,3)
      ITER=0
      NWSTP=1
  100 CONTINUE
      CALL STRESS(E,STRE,NEL,NS3,IELD,NS4,EPERM,NL,STA,STRST,
     +              ICSTR,SREAL,NS1,NS2,EALL,
     +IGMAT,NGL,STEEL,ICOMP,ICRACK,IEL,ISSC,FINISH,NWSTP,T)
      CALL FORSCT(NEL,FORCE,NS1,EALL,NS3,Y,NL,NGL,DIM,ICOMP,
     +       IATYPE,IGMAT,IEL,ICRACK,STRE,AREA,STEEL,STA,
     +       INCLUD,FINCAB,CABLE,YCABLE,NNOD,GTP,NOWPRO)
C
C               UPDATE THE EXTERNAL LOAD VECTOR
C
      DO 400 J=1,NODE3
      CNF(J,2)=CNF(J,1)+CNF(J,3)*ISTEP/NSTEPS
  400 CONTINUE
C
      CALL CHEKEQ(FORCE,CNF,NEL,ISTOP,IEL,DCL,DIM,B,AREA,X,NNOD,
     +             NVAR,NODE3,NDISP,FINCAB,INCLUD,BC)
      IF(ISTOP.EQ.1)GO TO 200
      CALL RESOLV(NDISP,NBAND,ST,B)
      ITER=ITER+1
      NTITER=NTITER+1
      CALL DISPLA(B,NDISP,NVAR,NNOD,DISP,SDISP)
      CALL STRAIN(E,DIM,NEL,STEEL,IEL,NVAR,IGMAT,IATYPE,IPRET,NNOD,
     + X,ICOMP,STA,STRB,STRST,NGL,NDL,NL,NS1,NS2,Y,GTP,NOWPRO)
      IF(LOCA(LC,1).NE.7)THEN
      DO 5555 NE=1,NEL
      DO 5556 L=1,NL
      STRLC(NE,L)=STRLC(NE,L)+STRST(NE,L)
 5556 CONTINUE
 5555 CONTINUE
      END IF
      IF(IGMAT.EQ.1)THEN
      IF(INCLUD.EQ.1)THEN
      CALL MCDCAB(CABLE,YCABLE,B,NEL,IEL,NVAR,X,NNOD,E,CABSST,NWSTP,
     +              NODE3)
      IF(NOWPRO.EQ.1.AND.IPRET.EQ.1)THEN
      DO 8000 JK=1,NEL
      FINCAB(JK,1)=CABLE(JK,3)
 8000 CONTINUE
      END IF
      END IF
      END IF
      IF(ITER.GE.500)THEN
      FINISH=1
```

```
      GO TO 300
      END IF
      NNSTP=0
      GO TO 100
  200 CONTINUE
      DO 10 I=1,NNOD
      DO 20 J=1,3
      JA=NVAR(I,J)
      IF(JA.NE.0)B(JA)=DISP(I,J)
   20 CONTINUE
   10 CONTINUE
  300 CONTINUE
      RETURN
      END
C*****************************************************************

      SUBROUTINE DISPLA(B,NDISP,NVAR,NNOD,DISP,SDISP)
C*****************************************************************
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION B(1),NVAR(NNOD,3),DISP(NNOD,3),SDISP(NNOD,3)
      DO 200 I=1,NNOD
      DO 100 J=1,3
      JA=NVAR(I,J)
      IF(JA.EQ.0)THEN
      DISP(I,J)=0
      SDISP(I,J)=0
      ELSE
      DISP(I,J)=DISP(I,J)+B(JA)
      SDISP(I,J)=SDISP(I,J)+B(JA)
      END IF
  100 CONTINUE
  200 CONTINUE
      RETURN
      END
C*****************************************************************

      SUBROUTINE MOCURV(DCM,NCH3,NCHEL,NEL,FORCE,SDISP,NNOD,
     *          STRB,ITNST,ICHECK,DIM,IGMAT,IEL,ITER,SALPHA,TIME)
C*****************************************************************
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION DCM(300,NCH3),FORCE(NEL,3),SDISP(NNOD,3),STRB(NEL,8),
     *          ICHECK(NCHEL),DIM(NEL,8),IEL(NEL,3)
      DO 10 NK=1,NCHEL
      NEC=ICHECK(NK)
      GH=DIM(NEC,4)
      IF(IGMAT.NE.0) GH=GH+DIM(NEC,6)+DIM(NEC,8)
      N1=IEL(NEC,1)
      N2=IEL(NEC,2)
      CURV=(STRB(NEC,1)-STRB(NEC,2))/GH
      IF(IEL(NEC,3).EQ.1)CURV=(STRB(NEC,3)-STRB(NEC,4))/DIM(NEC,2)
      DISP=(SDISP(N1,2)+SDISP(N2,2))/2
      AMOM=FORCE(NEC,2)
      DCM(ITNST,NK*6-5)=AMOM
      DCM(ITNST,NK*6-4)=CURV
      DCM(ITNST,NK*6-3)=DISP
      DCM(ITNST,NK*6-2)=SALPHA
      DCM(ITNST,NK*6-1)=TIME
      DCM(ITNST,NK*6)=ITER
   10 CONTINUE
      RETURN
      END
C*****************************************************************

      SUBROUTINE MODGD(NNOD,NSUP,NVAR,IVAR,NDISP,PREDIS,MODIFY)
C*****************************************************************
C     THIS SUBROUTINE CALCULATES THE NEW GLOBAL DISPLACEMENTS
C     THAT INCLUDE THE PRESCRIBED SUPPORT DISPLACEMENTS
C
      IMPLICIT REAL*8 (A-H,O-Z)
      DIMENSION NVAR(NNOD,3),IVAR(NNOD,3),PREDIS(NSUP,2)
C
C                 CHANGE NODE CONDITION AT SUPPORTS
C
      DO 10 I=1,NSUP
      IF(PREDIS(I,2).NE.0) THEN
      NODE=PREDIS(I,1)
      IF(MODIFY.EQ.0) IVAR(NODE,2)=0
      IF(MODIFY.EQ.1) IVAR(NODE,2)=1
      END IF
   10 CONTINUE
C                 OBTAIN NEW NVAR AND NDISP
      NDISP=0
      DO 11 I=1,NNOD
      DO 9 J=1,3
      NVARIJ=IVAR(I,J)
      IF(NVARIJ.EQ.0)THEN
      NDISP=NDISP+1
      NVAR(I,J)=NDISP
      ELSE
      NVAR(I,J)=0
      END IF
    9 CONTINUE
   11 CONTINUE
      RETURN
      END
C*****************************************************************

      SUBROUTINE NEWSOL(ST,B,NDISP,NBAND,NVAR,NNOD,NSUP,PREDIS)
C*****************************************************************
C  *  THIS SUBROUTINE CHANGES ST AND B FOR A NEW SOLUTION OF DISPL.
C
      IMPLICIT REAL*8 (A-H,O-Z)
      DIMENSION ST(NDISP,NBAND),B(NDISP),NVAR(NNOD,3),PREDIS(NSUP,2)
      DO 10 I=1,NSUP
      IF(PREDIS(I,2).NE.0) THEN
      NODE=PREDIS(I,1)
      IGDISP=NVAR(NODE,2)
      ST(IGDISP,1)=ST(IGDISP,1)*1.E12
      B(IGDISP)=ST(IGDISP,1)*PREDIS(I,2)
      END IF
   10 CONTINUE
      RETURN
      END
C*****************************************************************

      SUBROUTINE DELCAD(IGMAT,IATYPE,GAMAG,GAMAD,DIM,NEL,IEL,DELO)
C*****************************************************************
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION DIM(NEL,8),IEL(NEL,3),DELO(NEL,2)
C
```

```
C                                  STEEL GIBDER
C
      IF(IGMAT.EQ.0)THEN
      DO 10 I=1,NEL
      GA=DIM(I,3)
      DA=DIM(I,1)*DIM(I,2)
      DELO(I,2)=DA*GAMAD
      IF(IEL(I,3).EQ.0)THEN
      DELO(I,1)=GA*GAMAG
      ELSE
      DELO(I,1)=0
      END IF
   10 CONTINUE
      END IF
C                                  CONCRETE GIRDER
      IF(IGMAT.NE.0)THEN
      DO 20 I=1,NEL
      GA=DIM(I,3)*DIM(I,4)+DIM(I,5)*DIM(I,6)+DIM(I,7)*DIM(I,8)
      DA=DIM(I,1)*DIM(I,2)
      DELO(I,2)=DA*GAMAD
      IF(IEL(I,3).EQ.0)THEN
      DELO(I,1)=GA*GAMAG
      ELSE
      DELO(I,1)=0
      END IF
   20 CONTINUE
      END IF
      WRITE(3,2222)
 2222 FORMAT(/,130('*'),/)
      WRITE(3,60)
   60 FORMAT(20X,'D E A D   L O A D')
      WRITE(3,1111)
 1111 FORMAT(/,130('-'),/)
      WRITE(3,70)
   70 FORMAT(1X,'ELEM #',13X,'GIRDER',13X,'DECK',///)
      DO 80 I=1,NEL
      WRITE(3,90)I,DELO(I,1),DELO(I,2)
   90 FORMAT(4X,I3,8X,D15.8,5X,D15.8,/)
   80 CONTINUE
      RETURN
      END
C*****************************************************************

      SUBROUTINE SECAO(IGMAT,IATYPE,GAMAG,GAMAD,DIM,E,STEEL,
     *                 NEL,IEL,AREA)
C*****************************************************************
C     THIS SUBROUTINE CALCULATES: YB,AREA,A.MOM AND M.INERT.
C     OF UNCRACKED SECTIONS IN STEEL AND CONCRETE,COMPOSITE OR NOT
C     VARIABLE SIGNIFICANCE:     A   AREA
C                                B   BASE,BOTTOM
C                                C   COMPOSITE
C                                D   DECK
C                                G   GIRDER
C                                H   HEIGHT
C                                I   INERTIA ( TO BASE )
C                                M   AREA MOM ( TO BASE )
C                                N   MODULAR RATIO
C                                P   PRESTRESSED
C                                R   REINFORCED
C                                S   STEEL
C                                T   TRANSFORMED,TOP
C                                W   WEB
C                                Y   CENTROID ( TO BASE )
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION DIM(NEL,8),STEEL(NEL,6),E(4,6),IEL(NEL,3),AREA(NEL,8)
       DN=E(4,1)/E(3,1)
      RSN=E(2,1)/E(3,1)
      DO 100 JK=1,2
      IF(JK.EQ.1)ICOMP=0
      IF(JK.EQ.2)ICOMP=1
C                            STEEL GIRDER,UNCRACKED DECK
      IF(IGMAT.EQ.0)THEN
      DO 10 I=1,NEL
      GA=DIM(I,3)
      DA=DIM(I,1)*DIM(I,2)
      TDA=(DA*DN+STEEL(I,1)*RSN)*ICOMP
      TCA=GA+TDA
      GM=GA*DIM(I,4)/2
      TDM=TDA*(DIM(I,4)+DIM(I,2)/2)
      TCM=GM+TDM
      TCY=TCM/TCA
      GI=DIM(I,5)+GA*(DIM(I,4)/2)**2
      TDI=(DN*DIM(I,1)*DIM(I,2)**3)/12+TDA*(DIM(I,4)+DIM(I,2)/2)**2
      TCI=GI+TDI*ICOMP
      IF(IEL(I,3).EQ.0)THEN
      AREA(I,4*JK-3)=TCY
      AREA(I,4*JK-2)=TCA
      AREA(I,4*JK-1)=TCM
      AREA(I,4*JK)=TCI-TCA*TCY**2
      ELSE
      AREA(I,4*JK-3)=0
      AREA(I,4*JK-2)=TDA
      AREA(I,4*JK-1)=0
      AREA(I,4*JK)=0
      END IF
   10 CONTINUE
      END IF
C     *                      CONCRETE GIRDER,UNCRACKED
      IF(IGMAT.NE.0)THEN
      DO 20 I=1,NEL
      BD=DIM(I,1)
      HD=DIM(I,2)
      BT=DIM(I,3)
      HT=DIM(I,4)
      BW=DIM(I,5)
      HW=DIM(I,6)
      BB=DIM(I,7)
      HB=DIM(I,8)
      GA=BT*HT+BW*HW+BB*HB
      TRSAT=STEEL(I,3)*RSN
      TRSAB=STEEL(I,5)*RSN
      TGA=GA+TRSAT+TRSAB
      DA=BD*HD
      TDA=(DA*DN+STEEL(I,1)*RSN)*ICOMP
      TCA=TGA+TDA
      TDM=TDA*(HT+HW+HB+HD/2)
      GM=BT*HT*(HW+HB+HT/2)+BW*HW*(HB+HW/2)+BB*HB*HB/2
      TGM=GM+TRSAT*STEEL(I,4)+TRSAB*STEEL(I,6)
      TCM=TDM+TGM
      TCY=TCM/TCA
```

```
      TDI=(DW*DD*HD**3)*ICOMP/12+TDA*(HT+HW+HB+HD/2)**2
      GI=(BT*HT**3)/12+(BT*HT)*(HW+HB+HT/2)**2+
     *    (BW*HW**3)/12+(BW*HW)*(HB+HW/2)**2+
     *    (EB*HB**3)/12+(EB*HB)*(HB/2)**2
      TGI=GI+TRSAT*STEEL(I,4)**2+TRSAB*STEEL(1,6)**2
      TCI=TDI+TGI
      IF(IEL(I,3).EQ.0)THEN
      AREA(I,4*JK-3)=TCY
      AREA(I,4*JK-2)=TCA
      AREA(I,4*JK-1)=TCM
      AREA(I,4*JK)=TCI-TCA*TCY**2
      ELSE
      AREA(I,4*JK-3)=0
      AREA(I,4*JK-2)=TDA
      AREA(I,4*JK-1)=0
      AREA(I,4*JK)=0
      END IF
   20 CONTINUE
      END IF
  100 CONTINUE
      WRITE(3,2222)
 2222 FORMAT(/,130('*'),/)
      WRITE(3,30)
   30 FORMAT(10X,'O R I G I N A L   S E C T I O N   P R O P E R T I E S'
     *        ,10X,'( TRANSFORMED )',//)
      WRITE(3,40)
   40 FORMAT(20X,'( NON-COMPOSITE SECTION )',
     *        40X,'( COMPOSITE SECTION )')
      WRITE(3,1111)
 1111 FORMAT(/,130('-'),/)
      WRITE(3,50)
   50 FORMAT(1X,'ELEM #',4X,'CENTROID',10X,'AREA',9X,'AREA MOM.',
     *        8X,'INERTIA',6X,'CENTROID',10X,'AREA',9X,'AREA MOM.',
     *        8X,'INERTIA',//)
      DO 60 I=1,NEL
      WRITE(3,70)I,(AREA(I,J),J=1,8)
   70 FORMAT(4X,I3,8(2X,D13.6),/)
   60 CONTINUE
      RETURN
      END
C***********************************************************************

      SUBROUTINE NWAREA(NEL,DIM,ICOMP,IATYPE,IGMAT,IEL,NGL,NL,STRE,
     *                  ICRACK,EALL,STEEL,NS3,Y,AREA,E,FINISH)
C***********************************************************************
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION DIM(NEL,8),IEL(NEL,3),STRE(NEL,NS3),ICRACK(NEL,NL),
     *        EALL(NEL,NS3),STEEL(NEL,6),Y(NL,3),AREA(NEL,8),E(4,6)
      DO 10 NE=1,NEL
      DO 2 J=1,8
      AREA(NE,J)=0
    2 CONTINUE
      EA=0
      ES=0
      EI=0
      GA=0
      ITYPE=IEL(NE,3)
      CALL LAYER(DIM,ICOMP,IATYPE,IGMAT,ITYPE,NEL,NE,Y,TH,NGL,NL)
      IF(ITYPE.EQ.1)GO TO 100
      IF(ICOMP.EQ.0)LIM=NGL
      IF(ICOMP.EQ.1)LIM=NL
      DO 20 L=1,LIM
      IF(EALL(NE,L).LT.0)THEN
      EMCD=0
      ELSE
      EMCD=EALL(NE,L)
      END IF
      IF(ICRACK(NE,L).EQ.0)THEN
      IF(STRE(NE,L).GE.0)GO TO 20
      END IF
      EA=EA+Y(L,2)*EMOD
      ES=ES+Y(L,1)*Y(L,2)*EMCD
      EI=EI+(Y(L,2)**3/12/Y(L,3)**2+Y(L,2)*Y(L,1)**2)*EMCD
   20 CONTINUE
      IF(ICOMP.EQ.0)LIM=2
      IF(ICOMP.EQ.1)LIM=1
      DO 30 K=LIM,3
      J=2*K-1
      EA=EA+STEEL(NE,J)*EALL(NE,NL+K)
      ES=ES+STEEL(NE,J)*EALL(NE,NL+K)*STEEL(NE,J+1)
      EI=EI+STEEL(NE,J)*EALL(NE,NL+K)*STEEL(NE,J+1)**2
   30 CONTINUE
      GO TO 200
  100 IF(ICOMP.EQ.0)GO TO 10
      LIM=NGL+1
      DO 40 L=LIM,NL
      IF(EALL(NE,L).LT.0)THEN
      EMCD=0
      ELSE
      EMCD=EALL(NE,L)
      END IF
      IF(ICRACK(NE,L).EQ.0)THEN
      IF(STRE(NE,L).GE.0)GO TO 40
      END IF
      EA=EA+Y(L,2)*EMOD
   40 CONTINUE
      EA=EA+STEEL(NE,1)*EALL(NE,NL+1)
  200 CONTINUE
      IF(ITYPE.EQ.0)THEN
      IF(EA.EQ.0)THEN
      FINISH=7
      GO TO 1000
      ELSE
      AREA(NE,1)=ES/EA
      AREA(NE,2)=EA/E(3,1)
      AREA(NE,3)=ES/E(3,1)
      AREA(NE,4)=EI/E(3,1)
      AREA(NE,5)=EA
      AREA(NE,6)=ES
      AREA(NE,7)=EI
      V=0.2
      AREA(NE,8)=EA/(2*(1+V))
      END IF
      ELSE
      AREA(NE,5)=EA
      END IF
   10 CONTINUE
 1000 CONTINUE
      RETURN
      END
```

```
C*******************************************************************
      SUBROUTINE EQLOAD(NNOD,NEL,IEL,DLOAD,CLOAD,X,B,NVAB)
C*******************************************************************
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION IEL(NEL,3),CLOAD(NNOD,3),DLOAD(NEL,3),
     *          ELOAD(2,3),X(NNOD,2),B(1),NVAB(NNOD,3)
      REAL*8 L
C
C          CLOAD = NODAL FORCES
C          DLOAD = DISTRIBUTED FORCES
C
      DO 10 I=1,NEL
C
C          AP=POSITION OF THE VERT. FORCE IN THE ELEMENT
C
      AP=DLOAD(I,3)
      N1=IEL(I,1)
      N2=IEL(I,2)
      L=X(N2,1)-X(N1,1)
      BP=L-AP
      DO 1 K=1,2
      DO 2 J=1,3
      ELOAD(K,J)=0
    2 CONTINUE
    1 CONTINUE
      C1=(3*AP+BP)/L**3
      C2=(AP+3*BP)/L**3
C
C           DISTRIB (,1) AND CONC (,2) VERTICAL FORCES ARE
C            TRANSFORMED TO EQUIVALENT NODAL FORCES
C
      ELOAD(1,2)=-DLOAD(I,2)*C1*BP**2-DLOAD(I,1)*L/2
      ELOAD(2,2)=-DLOAD(I,2)*C2*AP**2-DLOAD(I,1)*L/2
      DO 20 J=1,3
C
C          NODAL FORCES = NODAL LOADS + EQUIVALENT NODAL LOADS
C
      CLOAD(N1,J)=CLOAD(N1,J)+ELOAD(1,J)
      CLOAD(N2,J)=CLOAD(N2,J)+ELOAD(2,J)
   20 CONTINUE
   10 CONTINUE
C
C          B - STORES THE NODAL FORCES
C
      NDIS=0
      DO 11 I=1,NNOD
      DO 9 J=1,3
      NVABIJ=NVAB(I,J)
      IF(NVABIJ.NE.0)THEN
      NDIS=NDIS+1
      B(NDIS)=CLOAD(I,J)
      END IF
    9 CONTINUE
   11 CONTINUE
      RETURN
      END
C *******************************************************************

      SUBROUTINE ADSTIF(NNOD,NDISP,NBAND,NEL,IEL,
     *                  NVAB,X,ST,BC,DIM,AREA,YCABLE,CABLE,INCLUD,
     *                  NSUP3,NSUP,PREDIS)
C*******************************************************************
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION IEL(NEL,3),ELST(6,6),NVAB(NNOD,3),ST(NDISP,NBAND),
     *X(NNOD,2),DIM(NEL,8),AREA(NEL,8),YCABLE(NNOD),CABLE(NEL,7)
     *,PREDIS(NSUP,2)
      INTEGER EN,DISP
      DO 700 I=1,NDISP
      DO 600 J=1,NBAND
      ST(I,J)=0
  600 CONTINUE
  700 CONTINUE
      DO 500 I1=1,NEL
      EN=I1
      CALL ELSTIF(X,ELST,NNOD,NEL,IEL,EN,DIM,AREA,YCABLE,
     *            CABLE,INCLUD)
      DO 400 J1=1,2
      NODE1=IEL(I1,J1)
      DO 300 K1=1,3
      IVAB1=NVAB(NODE1,K1)
      IF(IVAB1.EQ.0) GO TO 300
      JK1=3*(J1-1)+K1
      DO 200 J2=J1,2
      NODE2=IEL(I1,J2)
      JK=1
      IF(J2.EQ.J1) JK=K1
      DO 150 K2=JK,3
      IVAB2=NVAB(NODE2,K2)
      IF(IVAB2.EQ.0) GO TO 150
      JK2=3*(J2-1)+K2
      IV1=IVAB1
      IV2=IVAB2
      IF(IVAB2.GE.IVAB1) GO TO 100
      IV1=IVAB2
      IV2=IVAB1
  100 IV2=IV2-IV1+1
      ST(IV1,IV2)=ST(IV1,IV2)+ELST(JK1,JK2)
  150 CONTINUE
  200 CONTINUE
  300 CONTINUE
  400 CONTINUE
  500 CONTINUE
C                         ADD BEARING COEFFICIENT
      IF(BC.EQ.0) GO TO 900
      DO 800 I=1,NNOD
      IF(NVAB(I,2).EQ.0.AND.NVAB(I,1).GT.0)THEN
      DISP=NVAB(I,1)
      ST(DISP,1)=ST(DISP,1)+BC
      END IF
  800 CONTINUE
  900 CONTINUE
      RETURN
      END
C *******************************************************************

      SUBROUTINE ELSTIF(X,ST,NNOD,NEL,IEL,EN,DIM,AREA,
     *                  YCABLE,CABLE,INCLUD)
C*******************************************************************
      IMPLICIT REAL*8(A-H,O-Z)
```

```
      DIMENSION X(NNOD,2),ST(6,6),IEL(NEL,3),CS(6,6)
     *     ,DIM(NEL,8),AREA(NEL,8),YCABLE(NNOD),CABLE(NEL,7)
      REAL*8 L
      INTEGER EN,TYPE
      DO 10 I=1,6
      DO 20 J=1,6
      ST(I,J)=0
      CS(I,J)=0
   20 CONTINUE
   10 CONTINUE
      N1=IEL(EN,1)
      N2=IEL(EN,2)
      L=X(N2,1)-X(N1,1)
      Y1=X(N1,2)
      Y2=X(N2,2)
      TYPE=IEL(EN,3)
C
C       GIRDER ELEMENT STIFFNESS MATRIX
C
      IF(TYPE.EQ.0)THEN
      EA=AREA(EN,5)
      ES=AREA(EN,6)
      EI=AREA(EN,7)
      GA=AREA(EN,8)
      ST(1,1)=EA/L
      ST(1,3)=-ES/L-EA*Y1/L
      ST(3,1)=-ES/L-EA*Y1/L
      ST(1,4)=-EA/L
      ST(4,1)=-EA/L
      ST(1,6)=ES/L+EA*Y2/L
      ST(6,1)=ES/L+EA*Y2/L
      ST(2,2)=GA/L
      ST(2,3)=GA/2
      ST(3,2)=GA/2
      ST(2,5)=-GA/L
      ST(5,2)=-GA/L
      ST(2,6)=GA/2
      ST(6,2)=GA/2
      ST(3,3)=EI/L+GA*L/4+(EA*Y2**2+2*ES*Y1)/L
      ST(3,4)=ES/L+EA*Y1/L
      ST(4,3)=ES/L+EA*Y1/L
      ST(3,5)=-GA/2
      ST(5,3)=-GA/2
      ST(3,6)=-EI/L+GA*L/4-(EA*Y1*Y2+ES*Y1+ES*Y2)/L
      ST(6,3)=-EI/L+GA*L/4-(EA*Y1*Y2+ES*Y1+ES*Y2)/L
      ST(4,4)=EA/L
      ST(4,6)=-ES/L-EA*Y2/L
      ST(6,4)=-ES/L-EA*Y2/L
      ST(5,5)=GA/L
      ST(5,6)=-GA/2
      ST(6,5)=-GA/2
      ST(6,6)=EI/L+GA*L/4+(EA*Y2**2+2*ES*Y2)/L
C
C         PRESTRESSING CABLE STIFFNESS
C
      IF(INCLUD.EQ.0.OR.CABLE(EN,4).EQ.0)GO TO 100
      ALPHA=CABLE(EN,1)
      ACCS=DCOS(ALPHA)
      ASIN=DSIN(ALPHA)
      YP1=YCABLE(N1)+Y1
```

```
      YP2=YCABLE(N2)+Y2
      AEL=CABLE(EN,4)*CABLE(EN,7)/CABLE(EN,2)
      CS(1,1)=ACCS**2
      CS(4,4)=ACOS**2
      CS(4,1)=-ACOS**2
      CS(1,4)=-ACCS**2
      CS(2,2)=ASIN**2
      CS(5,5)=ASIN**2
      CS(2,5)=-ASIN**2
      CS(5,2)=-ASIN**2
      CS(1,5)=ASIN*ACOS
      CS(5,1)=ASIN*ACOS
      CS(2,4)=ASIN*ACOS
      CS(4,2)=ASIN*ACCS
      CS(1,2)=-ASIN*ACOS
      CS(2,1)=-ASIN*ACCS
      CS(4,5)=-ASIN*ACOS
      CS(5,4)=-ASIN*ACOS
      CS(3,4)=YP1*ACCS**2
      CS(4,3)=YP1*ACCS**2
      CS(1,3)=-YP1*ACOS**2
      CS(3,1)=-YP1*ACCS**2
      CS(3,2)=YP1*ASIN*ACOS
      CS(2,3)=YP1*ASIN*ACOS
      CS(3,5)=-YP1*ASIN*ACOS
      CS(5,3)=-YP1*ASIN*ACOS
      CS(3,3)=(YP1*ACCS)**2
      CS(1,6)=YP2*ACCS**2
      CS(6,1)=YP2*ACCS**2
      CS(4,6)=-YP2*ACCS**2
      CS(6,4)=-YP2*ACCS**2
      CS(5,6)=YP2*ASIN*ACOS
      CS(6,5)=YP2*ASIN*ACOS
      CS(2,6)=-YP2*ASIN*ACOS
      CS(6,2)=-YP2*ASIN*ACOS
      CS(3,6)=-YP1*YP2*ACOS**2
      CS(6,3)=-YP1*YP2*ACOS**2
      CS(6,6)=(YP2*ACCS)**2
      DO 40 I=1,6
      DO 50 J=1,6
      ST(I,J)=ST(I,J)+CS(I,J)*AEL
   50 CONTINUE
   40 CONTINUE
      ELSE
C
C          CONECTION ELEMENT STIFFNESS MATRIX
C
      H1=DIM(EN,3)+Y1
      H2=DIM(EN,4)+Y2
      EA=AREA(EN,5)/L
      ST(1,1)=EA
      ST(4,4)=EA
      ST(1,4)=-EA
      ST(4,1)=-EA
      ST(1,6)=EA*H2
      ST(6,1)=EA*H2
      ST(4,3)=EA*H1
      ST(3,4)=EA*H1
      ST(1,3)=-EA*H1
      ST(3,1)=-EA*H1
```

```
      ST(4,6)=-EA*H2
      ST(6,4)=-EA*H2
      ST(3,3)=EA*H1*H1
      ST(6,6)=EA*H2*H2
      ST(3,6)=-EA*H1*H2
      ST(6,3)=-EA*H1*H2
      END IF
  100 RETURN
      END
C*******************************************************************

      SUBROUTINE SCLVE (NEQ,NBAND,A,B)
C*******************************************************************
C
C           A = GLCBAL STIFFNESS MATRIX
C           B = INPUT AS THE NODAL FORCES
C               OUTPUT AS THE NODAL DISPLACEMENTS
C
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION A(NEQ,NBAND),B(NEQ)
      NEQ1=NEQ-1
      DO 400 I=1,NEQ1
      DIAG=A(I,1)
      IF(DIAG.GT.0.000000001)GO TO 100
      WRITE(3,1000)I,DIAG
 1000 FORMAT(5X,'EQUATION #',I3,' HAS DIAG TERM=',D20.13,///)
      CALL EXIT
  100 CONTINUE
      II=I+1
      IJ=I+NBAND-1
      IF(IJ.GT.NEQ)IJ=NEQ
      JJ=1
      DO 300 J=II,IJ
      JJ=JJ+1
      COEF=A(I,JJ)
      IF(COEF.EQ.0)GO TO 300
      COEF=COEF/DIAG
      NB=NBAND+I-J
      JJJ=JJ-1
      DO 200 K=1,NB
      JJJ=JJJ+1
      A(J,K)=A(J,K)-COEF*A(I,JJJ)
  200 CONTINUE
      B(J)=B(J)-COEF*B(I)
      A(I,JJ)=COEF
  300 CONTINUE
      B(I)=B(I)/DIAG
  400 CONTINUE
      DIAG=A(NEQ,1)
      IF(DIAG.GT.0.000000001)GO TO 450
      WRITE(3,1000)NEQ,DIAG
      CALL EXIT
  450 CONTINUE
      B(NEQ)=B(NEQ)/DIAG
      I=NEQ
      DO 600 II=1,NEQ1
      I=I-1
      JJ=I+1
      JK=I+NBAND-1
      IF(JK.GT.NEQ)JK=NEQ
      KK=1
      DO 500 J=JJ,JK
      KK=KK+1
      B(I)=B(I)-A(I,KK)*B(J)
  500 CONTINUE
  600 CONTINUE
      RETURN
      END
C*******************************************************************

      SUBROUTINE RESCLV(NEQ,NBAND,A,B)
C*******************************************************************
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION A(NEQ,NBAND),B(NEQ)
      NEQ1=NEQ-1
      DO 400 I=1,NEQ1
      II=I+1
      IJ=I+NBAND-1
      IF(IJ.GT.NEQ)IJ=NEQ
      JJ=1
      DO 300 J=II,IJ
      JJ=JJ+1
      B(J)=B(J)-A(I,JJ)*B(I)
  300 CONTINUE
      B(I)=B(I)/A(I,1)
  400 CONTINUE
      B(NEQ)=B(NEQ)/A(NEQ,1)
      I=NEQ
      DO 600 II=1,NEQ1
      I=I-1
      JJ=I+1
      JK=I+NBAND-1
      IF(JK.GT.NEQ)JK=NEQ
      KK=1
      DO 500 J=JJ,JK
      KK=KK+1
      B(I)=B(I)-A(I,KK)*B(J)
  500 CONTINUE
  600 CONTINUE
      RETURN
      END
C*******************************************************************

      SUBROUTINE STRAIN(E,DIM,NEL,STEEL,IEL,NVAR,IGMAT,IATYPE,IPRET,
     *NNOD,X,ICOMP,STA,STRB,STRST,NG1,NDL,NL,NS1,NS2,Y,GTP,NOWPRO)
C*******************************************************************
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION B(1),DIM(NEL,M),STEEL(NEL,6),IEL(NEL,3),
     *          NVAR(NNOD,3),DISP(6),STRB(NEL,8),STA(NEL,NS1),
     *          X(NNOD,2),Y(NL,3),STRST(NEL,NS2),GTP(NEL)
      INTEGER EN,TYPE
      DO 10 I=1,NEL
      DO 11 JK=1,NS2
      STRST(I,JK)=0
   11 CONTINUE
      EN=I
      DO 20 J=1,3
      N1=IEL(I,1)
      JA=NVAR(N1,J)
      IF(JA.LE.0)THEN
```

```
      DISP(J)=0
      ELSE
      DISP(J)=B(JA)
      END IF
      N2=IEL(I,2)
      J3=J+3
      JA=NVAR(N2,J)
      IF(JA.EQ.0)THEN
      DISP(J3)=0
      ELSE
      DISP(J3)=B(JA)
      END IF
   20 CONTINUE
      EL=X(N2,1)-X(N1,1)
      TYPE=IEL(I,3)
      CALL LAYER(DIM,ICOMP,IATYPE,IGMAT,TYPE,NEL,EN,Y,TH,NGL,NL)
      IF(TYPE.EQ.0)THEN
      DO 30 J=1,NGL
      Y1=Y(J,1)+X(N1,2)
      Y2=Y(J,1)+X(N2,2)
      EX=(DISP(4)-DISP(1)+Y1*DISP(3)-Y2*DISP(6))/EL
      STRST(I,J)=EX
      STA(I,J)=STA(I,J)+EX
   30 CONTINUE
      Y1=X(N1,2)
      Y2=X(N2,2)
      EX=(DISP(4)-DISP(1)+Y1*DISP(3)-Y2*DISP(6))/EL
      STRB(I,1)=STRB(I,1)+EX
      Y1=Y1+TH
      Y2=Y2+TH
      EX=(DISP(4)-DISP(1)+Y1*DISP(3)-Y2*DISP(6))/EL
      STRB(I,2)=STRB(I,2)+EX
      END IF
      IF(ICOMP.EQ.0) GO TO 1000
      LIM=NGL+1
      DO 40 J=LIM,NL
      IF(TYPE.EQ.0)THEN
      Y1=Y(J,1)+X(N1,2)
      Y2=Y(J,1)+X(N2,2)
      ELSE
      Y1=Y(J,1)+X(N1,2)+DIM(I,3)-DIM(I,2)/2
      Y2=Y(J,1)+X(N2,2)+DIM(I,4)-DIM(I,2)/2
      END IF
      EX=(DISP(4)-DISP(1)+Y1*DISP(3)-Y2*DISP(6))/EL
      STRST(I,J)=EX
      STA(I,J)=STA(I,J)+EX
   40 CONTINUE
      IF(TYPE.EQ.0)THEN
      Y1=TH+X(N1,2)
      Y2=TH+X(N2,2)
      EX=(DISP(4)-DISP(1)+Y1*DISP(3)-Y2*DISP(6))/EL
      STRB(I,3)=STRB(I,3)+EX
      Y1=Y1+DIM(I,2)
      Y2=Y2+DIM(I,2)
      EX=(DISP(4)-DISP(1)+Y1*DISP(3)-Y2*DISP(6))/EL
      STRB(I,4)=STRB(I,4)+EX
      ELSE
      Y1=X(N1,2)+DIM(I,3)-DIM(I,2)/2
      Y2=X(N2,2)+DIM(I,4)-DIM(I,2)/2
      EX=(DISP(4)-DISP(1)+Y1*DISP(3)-Y2*DISP(6))/EL
      STRB(I,3)=STRB(I,3)+EX
      Y1=Y1+DIM(I,2)
      Y2=Y2+DIM(I,2)
      EX=(DISP(4)-DISP(1)+Y1*DISP(3)-Y2*DISP(6))/EL
      STRB(I,4)=STRB(I,4)+EX
      END IF
      IF(STEEL(I,1).GT.0)THEN
      Y1=STEEL(I,2)+X(N1,2)
      Y2=STEEL(I,2)+X(N2,2)
      EX=(DISP(4)-DISP(1)+Y1*DISP(3)-Y2*DISP(6))/EL
      STRST(I,NL+1)=EX
      STA(I,NL+1)=STA(I,NL+1)+EX
      END IF
 1000 IF(STEEL(I,3).GT.0)THEN
      Y1=STEEL(I,4)+X(N1,2)
      Y2=STEEL(I,4)+X(N2,2)
      EX=(DISP(4)-DISP(1)+Y1*DISP(3)-Y2*DISP(6))/EL
      STRST(I,NL+2)=EX
      STA(I,NL+2)=STA(I,NL+2)+EX
      END IF
      IF(STEEL(I,5).GT.0)THEN
      Y1=STEEL(I,6)+X(N1,2)
      Y2=STEEL(I,6)+X(N2,2)
      EX=(DISP(4)-DISP(1)+Y1*DISP(3)-Y2*DISP(6))/EL
      STRST(I,NL+3)=EX
      STA(I,NL+3)=STA(I,NL+3)+EX
      END IF
      IF(TYPE.EQ.0) THEN
      GXY=(DISP(2)-DISP(5))/EL+(DISP(3)+DISP(6))/2
      IF(NCWPRO.EQ.1.AND.IPRET.EQ.0) GTP(I)=STA(I,NL+4)+GXY
      IF(NCWPRO.EQ.1.AND.IPRET.EQ.1) GTP(I)=STA(I,NL+4)
      STRST(I,NL+4)=GXY
      STA(I,NL+4)=STA(I,NL+4)+GXY
      END IF
      DO 60 J=1,4
      K=J+4
      STANEW=DABS(STRB(I,J))
      STAMAX=DABS(STRB(I,K))
      IF(STANEW.GT.STAMAX) STRB(I,K)=STRB(I,J)
   60 CONTINUE
   10 CONTINUE
      RETURN
      END
C*****************************************************************

      SUBROUTINE LVECTR(DCL,NEL,STRST,NS2,EALL,NS3,Y,NL,NGL,DIM,
     +                  ICOMP,IATYPE,IGMAT,IEL,ICRACK,STRE,AREA,
     +                  STEEL,INCLUD,CADSST,CABLE,YCABLE,NNOD,
     +                  NOWPLO,X,NVAR,B)
C*****************************************************************
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION DCL(NNOD,3),STRST(NEL,NS2),STEEL(NEL,6),EALL(NEL,NS3),
     +          Y(NL,3),DIM(NEL,8),IEL(NEL,3),STRE(NEL,NS3),
     +          AREA(NEL,8),ICRACK(NEL,NL),CADSST(NEL),CABLE(NEL,7),
     +          YCABLE(NNOD),X(NNOD,2),NVAR(NNOD,3),B(1)
      DO 5 I=1,NNOD
      DO 6 J=1,3
      DCL(I,J)=0
    6 CONTINUE
    5 CONTINUE
```

```
      DO 10 NE=1,NEL
      FN=0
      FM=0
      ITYPE=IEL(NE,3)
      CALL LAYER(DIM,ICOMP,IATYPE,IGMAT,ITYPE,NEL,NE,Y,TH,NGL,NL)
      IF(ITYPE.EQ.1)GO TO 100
      IF(ICOMP.EQ.0)LIM=NGL
      IF(ICOMP.EQ.1)LIM=NL
      DO 20 L=1,LIM
      IF(EALL(NE,L).LT.0)THEN
      EMCD=0
      ELSE
      EMCD=EALL(NE,L)
      END IF
      IF(ICRACK(NE,L).EQ.0)THEN
      IF(STRE(NE,L).GE.0)GO TO 20
      END IF
      FN=FN+STRST(NE,L)*EMOD*Y(L,2)
      FM=FM+STRST(NE,L)*EMOD*Y(L,2)*(AREA(NE,1)-Y(L,1))
   20 CONTINUE
      IF(ICOMP.EQ.0)LIM=2
      IF(ICOMP.EQ.1)LIM=1
      DO 30 K=LIM,3
      J=2*K-1
      FN=FN+STRST(NE,NL+K)*EALL(NE,NL+K)*STEEL(NE,J)
      FM=FM+STRST(NE,NL+K)*EALL(NE,NL+K)*STEEL(NE,J)*
     *      (AREA(NE,1)-STEEL(NE,J+1))
   30 CONTINUE
      GO TO 200
  100 IF(ICOMP.EQ.0)GO TO 10
      LIM=NGL+1
      DO 40 L=LIM,NL
      IF(EALL(NE,L).LT.0)THEN
      EMCD=0
      ELSE
      EMCD=EALL(NE,L)
      END IF
      IF(ICRACK(NE,L).EQ.0)THEN
      IF(STRE(NE,L).GE.0)GO TO 40
      END IF
      FN=FN+STRST(NE,L)*EMOD*Y(L,2)
   40 CONTINUE
      FN=FN+STRST(NE,NL+1)*EALL(NE,NL+1)*STEEL(NE,1)
  200 CONTINUE
      N1=IEL(NE,1)
      N2=IEL(NE,2)
      IF(INCLUD.EQ.1.AND.ITYPE.EQ.0)THEN
      ALFHA=CABLE(NE,1)
      F=CABSST(NE)*CABLE(NE,7)*CABLE(NE,4)
      ABM=AREA(NE,1)-(YCABLE(N1)+YCABLE(N2))/2
      FM=FM+F*DCOS(ALPHA)*ABM
      END IF
      AL=X(N2,1)-X(N1,1)
      IF(IEL(NE,3).EQ.0)THEN
      FM1=-FM+FN*(AREA(NE,1)+X(N1,2))
      FM2=-FM+FN*(AREA(NE,1)+X(N2,2))
      ELSE
      FM1=FN*(DIM(NE,3)+X(N1,2))
      FM2=FN*(DIM(NE,4)+X(N2,2))
      END IF
      DCL(N1,1)=DCL(N1,1)-FN
      DCL(N1,3)=DCL(N1,3)+FM1
      DCL(N2,1)=DCL(N2,1)+FN
      DCL(N2,3)=DCL(N2,3)-FM2
   10 CONTINUE
      DO 50 I=1,NNOD
      DO 60 J=1,3
      JA=NVAR(I,J)
      IF(JA.NE.0)B(JA)=DCL(I,J)
   60 CONTINUE
   50 CONTINUE
      RETURN
      END
C**********************************************************************

      SUBROUTINE FORSCT(NEL,FORCE,NS1,EALL,NS3,Y,NL,NGL,DIM,
     *          ICOMP,IATYPE,IGMAT,IEL,ICRACK,STRE,AREA,STEEL,STA,
     *          INCLUD,FINCAB,CABLE,YCABLE,NNOD,GTP,NOWPRO)
C**********************************************************************
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION FORCE(NEL,3),STEEL(NEL,6),EALL(NEL,NS3),GTP(NEL)
     *,Y(NL,3),DIM(NEL,8),IEL(NEL,3),STRE(NEL,NS3),AREA(NEL,8)
     *,ICRACK(NEL,NL),STA(NEL,NS1),FINCAB(NEL,3),CABLE(NEL,7),
     * YCABLE(NNOD)
C
C              STORE INITIAL PRIMARY MOMENTS
C
      IF(NOWPRO.EQ.1)THEN
      DO 1000 NE=1,NEL
      N1=IEL(NE,1)
      N2=IEL(NE,2)
      ALFHA=CABLE(NE,1)
      ABM=AREA(NE,1)-(YCABLE(N1)+YCABLE(N2))/2
      FINCAB(NE,2)=FINCAB(NE,1)*DCOS(ALPHA)*ABM
      FINCAB(NE,3)=FINCAB(NE,1)*DSIN(ALPHA)
 1000 CONTINUE
      END IF
C
      DO 10 NE=1,NEL
      FN=0
      FM=0
      FQ=0
      ITYPE=IEL(NE,3)
      CALL LAYER(DIM,ICOMP,IATYPE,IGMAT,ITYPE,NEL,NE,Y,TH,NGL,NL)
      IF(ITYPE.EQ.1)GO TO 100
      IF(ICOMP.EQ.0)LIM=NGL
      IF(ICOMP.EQ.1)LIM=NL
      DO 20 L=1,LIM
      IF(EALL(NE,L).LT.0)THEN
      EMCD=0
      ELSE
      EMCD=EALL(NE,L)
      END IF
      IF(ICRACK(NE,L).EQ.0)THEN
      IF(STRE(NE,L).GE.0)GO TO 20
      END IF
      FN=FN+STRE(NE,L)*Y(L,2)
      FM=FM+STRE(NE,L)*Y(L,2)*(AREA(NE,1)-Y(L,1))
      V=0.2
      G=EMCD/2/(1+V)
```

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      FQ=FQ+STA(NE,NS1)*G*Y(L,2)
   20 CONTINUE
      IF(ICOMP.EQ.0) LIM=2
      IF(ICOMP.EQ.1) LIM=1
      DO 30 K=LIM,3
      J=2*K-1
      FN=FN+STRE(NE,NL+K)*STEEL(NE,J)
      FM=FM+STRE(NE,NL+K)*STEEL(NE,J)*
     *        (AREA(NE,1)-STEEL(NE,J+1))
      G=EALL(NE,NL+K)/2/(1+V)
      FQ=FQ+STA(NE,NS1)*G*STEEL(NE,J)
   30 CONTINUE
      GO TO 200
  100 IF(ICOMP.EQ.0) THEN
      DO 101 JK=1,3
      FORCE(NE,JK)=0
  101 CONTINUE
      GO TO 10
      END IF
      LIM=NGL+1
      DO 40 L=LIM,NL
      IF(ICRACK(NE,L).EQ.0) THEN
      IF(STRE(NE,L).GE.0)GO TO 40
      END IF
      FN=FN+STRE(NE,L)*Y(L,2)
   40 CONTINUE
      FN=FN+STRE(NE,NL+1)*STEEL(NE,1)
      FM=0
      FQ=0
  200 CONTINUE
      IF(INCLUD.EQ.1) THEN
      IF(ITYPE.EQ.0) THEN
      N1=IEL(NE,1)
      N2=IEL(NE,2)
      ALFHA=CABLE(N2,1)
      F=CABLE(NE,3)
      ARM=AREA(NE,1)-(YCABLE(N1)+YCABLE(N2))/2
      FM=FM+F*DCOS(ALPHA)*ARM
      G=CABLE(NE,7)/2/(1+V)
      FQ=FQ+(STA(NE,NS1)-GTP(NE))*G*CABLE(NE,4)
      FN=FN+F
      END IF
      END IF
      FORCE(NE,1)=FN
      FORCE(NE,2)=FM
      FORCE(NE,3)=FQ
   10 CONTINUE
      RETURN
      END
C*******************************************************************

      SUBROUTINE CHEKEQ(FORCE,CNF,NEL,ISTOP,IEL,DCL,DIM,
     *           B,AREA,X,NNOD,NVAR,NODE3,NDISP,FINCAB,INCLUD,BC)
C*********************************************************************
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION FORCE(NEL,3),CNF(NODE3,3),B(1),
     *          IEL(NEL,3),AREA(NEL,6),X(NNOD,2),DCL(NNOD,3),
     *          NVAR(NNOD,3),FINCAB(NEL,3),DIM(NEL,8)
      DO 300 J=1,NNOD
      DO 400 K=1,3
      DCL(J,K)=0
  400 CONTINUE
  300 CONTINUE
      DO 30 I=1,NEL
      N1=IEL(I,1)
      N2=IEL(I,2)
      AL=X(N2,1)-X(N1,1)
      FX=-FORCE(I,1)
      FY=FORCE(I,3)
      IF(IEL(I,3).EQ.0)THEN
      FM1=-FORCE(I,2)+FORCE(I,1)*(AREA(I,1)+X(N1,2))+FORCE(I,3)*AL/2
      FM2=-FORCE(I,2)+FORCE(I,1)*(AREA(I,1)+X(N2,2))-FORCE(I,3)*AL/2
      ELSE
      FM1=FORCE(I,1)*(DIM(I,3)+X(N1,2))
      FM2=FORCE(I,1)*(DIM(I,4)+X(N2,2))
      END IF
      DCL(N1,1)=DCL(N1,1)+FX
      DCL(N1,2)=DCL(N1,2)+FY
      DCL(N1,3)=DCL(N1,3)+FM1
      DCL(N2,1)=DCL(N2,1)-FX
      DCL(N2,2)=DCL(N2,2)-FY
      DCL(N2,3)=DCL(N2,3)-FM2
      IF(INCLUD.EQ.1)THEN
      FORCE(I,1)=FORCE(I,1)-FINCAB(I,1)
      FORCE(I,2)=FORCE(I,2)-FINCAB(I,2)
      FORCE(I,3)=FORCE(I,3)-FINCAB(I,3)
      END IF
   30 CONTINUE
      DO 50 I=1,NNOD
      DO 60 J=1,3
      JA=NVAR(I,J)
      IF(JA.NE.0)B(JA)=DCL(I,J)
   60 CONTINUE
   50 CONTINUE
C                  ASSUMED APPROXIMATION LIMITS
      APROX=1
      SMALL=1
C
      ISTOP=1
      ANTL=(100-APROX)/100
      POSL=(100+APROX)/100
      DO 10 J=1,NNOD
      DO 20 K=1,3
      I=NVAR(J,K)
      IF(I.EQ.0)GO TO 20
      IF(K.EQ.1.AND.NVAR(J,2).EQ.0)THEN
      IF(BC.GT.0)GO TO 20
      END IF
      IF(ISTOP.EQ.0)GO TO 200
      IF(DABS(CNF(I,2)).LT.SMALL)THEN
      IF(DABS(B(I)).GT.SMALL)ISTOP=0
      ELSE
      IF(DABS(B(I)).LT.1.E-75)THEN
      ISTOP=0
      GO TO 200
      END IF
      RATE=B(I)/CNF(I,2)
      IF(RATL.GT.POSL)ISTOP=C
      IF(RATE.LT.ANTL)ISTOP=0
      END IF
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   20 CONTINUE
   10 CONTINUE
  200 IF(ISTOP.EQ.1) GO TO 100
      DO 40 I=1,NDISP
      B(I)=CMP(I,2)-B(I)
   40 CONTINUE
  100 CONTINUE
      RETURN
      END
C*****************************************************************

      SUBROUTINE STRESS(E,STRE,NEL,NS3,IELD,NS4,EPERM,NL,STA,
     +                 STRST,ICSTR,SREAL,NS1,NS2,EALL,IGMAT,NGL,
     +STEEL,ICOMP,ICBACK,IEL,ISSC,FINISH,NWSTP,T)
C*******************************************************************
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION E(4,6),STRE(NEL,NS3),IELD(NEL,NS4),EPERM(NEL,NL),
     +         STA(NEL,NS1),STRST(NEL,NS2),EALL(NEL,NS3),IEL(NEL,3),
     +          STEEL(NEL,6),ICBACK(NEL,NL),T(6)
      DO 10 NE=1,NEL
      IF(IEL(NE,3).EQ.1) GO TO 100
      DO 20 L=1,NGL
      WHICH=3
      ET=STA(NE,L)
      ES=STRST(NE,L)
      SIG=STRE(NE,L)
      ELAST=EALL(NE,L)
      IF(IGMAT.EQ.0) THEN
      YLD=IELD(NE,L)
      CALL BSTEEL(E,ET,ES,SIG,ELAST,YLD,WHICH,FINISH,NWSTP)
      IELD(NE,L)=YLD
      ELSE
      EPLAST=EPERM(NE,L)
      CRK=ICBACK(NE,L)
      CALL CONCRE(E,WHICH,ET,ES,ELAST,SIG,EPLAST,CRK,ISSC,FINISH,
     +            NWSTP,ICSTR,T,SREAL)
      EPERM(NE,L)=EPLAST
      ICBACK(NE,L)=CRK
      END IF
      STRE(NE,L)=SIG
      EALL(NE,L)=ELAST
   20 CONTINUE
      IF(IGMAT.EQ.0) GO TO 100
      DO 30 J=1,2
      IF(STEEL(NE,2*J+1).EQ.0) GO TO 30
      L=NL+1+J
      ET=STA(NE,L)
      ES=STRST(NE,L)
      SIG=STRE(NE,L)
      ELAST=EALL(NE,L)
      YLD=IELD(NE,NGL+1+J)
      WHICH=2
      CALL RSTEEL(E,ET,ES,SIG,ELAST,YLD,WHICH,FINISH,NWSTP)
      STRE(NE,L)=SIG
      EALL(NE,L)=ELAST
      IELD(NE,NGL+1+J)=YLD
   30 CONTINUE
  100 IF(ICOMP.EQ.0) GO TO 10
      LIM=NGL+1
      DO 40 L=LIM,NL
      WHICH=4
      ET=STA(NE,L)
      ES=STRST(NE,L)
      ELAST=EALL(NE,L)
      SIG=STRE(NE,L)
      EPLAST=EPERM(NE,L)
      CRK=ICBACK(NE,L)
      CALL CONCRE(E,WHICH,ET,ES,ELAST,SIG,EPLAST,CRK,ISSC,FINISH,
     +            NWSTP,ICSTR,T,SREAL)
      EALL(NE,L)=ELAST
      STRE(NE,L)=SIG
      EPERM(NE,L)=EPLAST
      ICBACK(NE,L)=CRK
   40 CONTINUE
      IF(STEEL(NE,1).EQ.0) GO TO 10
      ET=STA(NE,NL+1)
      ES=STRST(NE,NL+1)
      SIG=STRE(NE,NL+1)
      ELAST=EALL(NE,NL+1)
      YLD=IELD(NE,NGL+1)
      WHICH=2
      CALL RSTEEL(E,ET,ES,SIG,ELAST,YLD,WHICH,FINISH,NWSTP)
      STRE(NE,NL+1)=SIG
      EALL(NE,NL+1)=ELAST
      IELD(NE,NGL+1)=YLD
   10 CONTINUE
      RETURN
      END
C*****************************************************************

      SUBROUTINE LAYER(DIM,ICOMP,IATYPE,IGMAT,TYPE,NEL,EN,Y,TH,NGL,NL)
C*****************************************************************
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION DIM(NEL,8),Y(NL,3)
      INTEGER EN,TYPE
      DO 10 I=1,NL
      DO 20 J=1,3
      Y(I,J)=0
   20 CONTINUE
   10 CONTINUE
      TH=0
      IF(TYPE.EQ.1)GO TO 100
      IF(IGMAT.EQ.0.AND.IATYPE.EQ.1) THEN
      A=DIM(EN,3)
      TH=DIM(EN,4)
      TT=DIM(EN,6)
      WT=DIM(EN,7)
      BT=DIM(EN,8)
      Y(1,1)=BT*3/NGL
      Y(1,2)=((A-(TH-TT-BT)*WT)/(TT+BT))*BT/(NGL/6)
      Y(1,3)=Y(1,2)/BT/(NGL/6)
      DL=BT*6/NGL
      LIM=NGL/6
      DO 25 I=2,LIM
      Y(I,1)=Y(I-1,1)+DL
      Y(I,2)=Y(1,2)
      Y(I,3)=Y(1,3)
   25 CONTINUE
      DL=(TH-TT-BT)/(NGL*2/3)
      Y(NGL/6+1,1)=BT+DL/2
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      Y(NGL/6+1,2)=DL*WT
      Y(NGL/6+1,3)=WT
      LIMI=NGL/6+2
      LIMF=NGL*5/6
      DO 30 I=LIMI,LIMF
      Y(I,1)=Y(I-1,1)+DL
      Y(I,2)=DL*WT
      Y(I,3)=WT
   30 CONTINUE
      Y(NGL*5/6+1,1)=(TH-TT)+TT*3/NGL
      Y(NGL*5/6+1,2)=Y(1,2)*TT/BT
      Y(NGL*5/6+1,3)=Y(1,3)
      DL=TT*6/NGL
      LIM=5*NGL/6+2
      DO 35 I=LIM,NGL
      Y(I,1)=Y(I-1,1)+DL
      Y(I,2)=Y(I-1,2)
      Y(I,3)=Y(I-1,3)
   35 CONTINUE
      ELSE
      IF(IATYPE.EQ.0)THEN
      B=DIM(EN,3)
      TH=DIM(EN,4)
      DL=(TH*3)/(NGL*4)
      Y(1,1)=DL/2
      Y(1,2)=DL*B
      Y(1,3)=B
      LIM=NGL/3
      DO 40 I=2,LIM
      Y(I,1)=Y(I-1,1)+DL
      Y(I,2)=DL*B
      Y(I,3)=B
   40 CONTINUE
      Y(LIM+1,1)=Y(LIM,1)+DL*1.5
      Y(LIM+1,2)=DL*2*B
      Y(LIM+1,3)=B
      LIMI=LIM+2
      LIMF=NGL/2
      DO 41 I=LIMI,LIMF
      Y(I,1)=Y(I-1,1)+DL*2
      Y(I,2)=DL*2*B
      Y(I,3)=B
   41 CONTINUE
      LIM=LIMF+1
      DO 42 I=LIM,NGL
      J=NGL-I+1
      Y(I,1)=TH-Y(J,1)
      Y(I,2)=Y(J,2)
      Y(I,3)=B
   42 CONTINUE
      ELSE
      TB=DIM(EN,3)
      TT=DIM(EN,4)
      WB=DIM(EN,5)
      WT=DIM(EN,6)
      BB=DIM(EN,7)
      BT=DIM(EN,8)
      TH=TT+WT+BT
      DL=BT/(NGL/4)
      Y(1,1)=DL/2
      Y(1,2)=BB*DL
      Y(1,3)=BB
      LIM=NGL/4
      DO 45 I=2,LIM
      Y(I,1)=Y(I-1,1)+DL
      Y(I,2)=Y(1,2)
      Y(I,3)=Y(1,3)
   45 CONTINUE
      DL=WT/(NGL/2)
      Y(NGL/4+1,1)=BT+DL/2
      Y(NGL/4+1,2)=DL*WB
      Y(NGL/4+1,3)=WB
      LIM1=NGL/4+2
      LIM2=3*NGL/4
      DO 50 I=LIM1,LIM2
      Y(I,1)=Y(I-1,1)+DL
      Y(I,2)=Y(NGL/4+1,2)
      Y(I,3)=Y(NGL/4+1,3)
   50 CONTINUE
      DL=TT/(NGL/4)
      Y(3*NGL/4+1,1)=BT+WT+DL/2
      Y(3*NGL/4+1,2)=TB*DL
      Y(3*NGL/4+1,3)=TB
      LIM=3*NGL/4+2
      DO 55 I=LIM,NGL
      Y(I,1)=Y(I-1,1)+DL
      Y(I,2)=Y(3*NGL/4+1,2)
      Y(I,3)=Y(3*NGL/4+1,3)
   55 CONTINUE
      END IF
      END IF
  100 IF(ICOMP.EQ.1)THEN
      DL=DIM(EN,2)/(NL-NGL)
      Y(NGL+1,1)=TH+DL/2
      Y(NGL+1,2)=DL*DIM(EN,1)
      Y(NGL+1,3)=DIM(EN,1)
      LIM=NGL+2
      DO 60 I=LIM,NL
      Y(I,1)=Y(I-1,1)+DL
      Y(I,2)=Y(NGL+1,2)
     *Y(I,3)=Y(NGL+1,3)
   60 CONTINUE
      END IF
      RETURN
      END
C **************************************************************************

      SUBROUTINE NWSTIF(NNOD,NNDISP,NBAND,NEL,IEL,
     *                  KVAR,X,ST,DC,DIM,AREA,YCABLE,CABLE,INCLUD,NODR)
C**************************************************************************
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION IEL(NEL,3),ELST(6,6),KVAR(NNOD,3),ST(NNDISP,NBAND),
     *X(NNOD,2),DIM(NEL,8),AREA(NEL,8),YCABLE(NNOD),CABLE(NEL,7)
      INTEGER EN,DISP
      DO 700 I=1,NNDISP
      DO 600 J=1,NBAND
      ST(I,J)=0
  600 CONTINUE
  700 CONTINUE
      DO 500 II=1,NEL
```

```
      EN=I1
      CALL ELSTIF(X,ELST,NNOD,NEL,IEL,EN,DIM,AREA,YCABLE,
     *            CABLE,INCLUD)
      DO 400 J1=1,2
      NODE1=IEL(I1,J1)
      DO 300 K1=1,3
      IVAR1=KVAR(NODE1,K1)
      IF(IVAR1.EQ.0)GO TO 300
      JK1=3*(J1-1)+K1
      DO 200 J2=J1,2
      NODE2=IEL(I1,J2)
      JK=1
      IF(J2.EQ.J1)JK=K1
      DO 150 K2=JK,3
      IVAR2=KVAR(NODE2,K2)
      IF(IVAR2.EQ.0)GO TO 150
      JK2=3*(J2-1)+K2
      IV1=IVAR1
      IV2=IVAR2
      IF(IVAR2.GE.IVAR1)GO TO 100
      IV1=IVAR2
      IV2=IVAR1
  100 IV2=IV2-IV1+1
      ST(IV1,IV2)=ST(IV1,IV2)+ELST(JK1,JK2)
  150 CONTINUE
  200 CONTINUE
  300 CONTINUE
  400 CONTINUE
  500 CONTINUE
C                          ADD BEARING COEFFICIENT
      IF(BC.EQ.0)THEN
      GO TO 900
      END IF
      DO 800 I=1,NNOD
      IF(KVAR(I,2).EQ.0) THEN
      IF(I.EQ.NODR)GO TO 800
      IF(KVAR(I,1).GT.0) THEN
      DISP=KVAR(I,1)
      ST(DISP,1)=ST(DISP,1)+BC
      END IF
      END IF
  800 CONTINUE
  900 CONTINUE
      RETURN
      END
C*********************************************************************

      SUBROUTINE FRACTN(NWSTP,AK12,DU,P2,P1,NNDISP,DENOM,ALPHA,
     *                  SALPHA,AK22,DRIVLL)
C*********************************************************************
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION AK12(1),DU(1),P1(1)
      IF(NWSTP.EQ.1) THEN
      DENOM=0
      DO 10 I=1,NNDISP
      DENOM=DENOM+AK12(I)*P1(I)
   10 CONTINUE
      DENOM=P2-DENOM
      A=AK22*DRIVLL
      ELSE
      A=-P2
      END IF
      B=0
      DO 20 I=1,NNDISP
      B=B+AK12(I)*DU(I)
   20 CONTINUE
      ALPHA=(B+A)/DENOM
      SALPHA=SALPHA+ALPHA
      RETURN
      END
C*********************************************************************

      SUBROUTINE SPLIT(NBAND,NVAR,NODR,NDISP,ST,NNOD,AK12,AK22)
C*********************************************************************
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION ST(NDISP,NBAND),NVAR(NNOD,3),AK12(1)
      DO 10 I=1,NDISP
      AK12(I)=0
   10 CONTINUE
      IDISP=NVAR(NODR,2)
      AK22=ST(IDISP,1)
      IDISP1=IDISP-1
      IF(IDISP.GE.NBAND) THEN
      IROW=IDISP-NBAND+1
      ICOL=NBAND
      ELSE
      IROW=1
      ICOL=IDISP
      END IF
      DO 20 I=IROW,IDISP1
      AK12(I)=ST(I,ICOL)
      ICOL=ICOL-1
   20 CONTINUE
      DO 30 ICOL=2,NBAND
      IDISP1=IDISP1+1
      AK12(IDISP1)=ST(IDISP,ICOL)
   30 CONTINUE
      RETURN
      END
C*********************************************************************

      SUBROUTINE CONCRE(E,WHICH,ET,ES,ELAST,SIG,EPLAST,CBK,ISSC,
     *                  FINISH,NWSTP,ICSTR,T,SREAL)
C*********************************************************************
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION E(4,6),T(6)
C                          CONCRETE AGE CORRECTION
      TO=T(WHICH-1)-28
      AGE=T(1)-TO
      A=2.00
      B=0.928571429
      FACT=AGE/(A+B*AGE)
C
      E0=E(WHICH,1)*DSQRT(FACT)
      ERU=-E(WHICH,6)
      ER=E(WHICH,3)
      TRS=E0*ER
      IF(ET.LE.ERU)FINISH=4
      SCV=0
      ECV=0
```

```
      IF (ISSC.EQ.0) THEN
      CALL HOGNES(E,ET,WHICH,SCV,ECV,FACT)
      END IF
      IF (ISSC.EQ.1) THEN
      CALL BILINR(E,ET,WHICH,SCV,ECV,FACT)
      END IF
      IF (CRK.NE.0) THEN
      IF (NWSTP.EQ.1.AND.ES.GT.0) ELAST=EO
      SIG=SIG+ELAST*ES
      IF (ISSC.EQ.1.AND.ELAST.GT.0) ELAST=EO
      IF (ISSC.EQ.0.AND.ICSTR.EQ.1) THEN
      CALL HOGSTR(E,WHICH,SIG,ELAST,FACT,ES)
      END IF
      IF (SIG.LT.SCV.AND.ICSTR.EQ.0) THEN
      SIG=SCV
      ELAST=ECV
      END IF
      IF (ET.GE.ER.AND.ICSTR.EQ.0) THEN
      SIG=0
      ELAST=EO
      EPLAST=ER
      CRK=0
      END IF
      IF (SIG.GE.TRS.AND.SREAL.EQ.1) THEN
      SIG=0
      ELAST=EO
      EPLAST=ET
      CRK=0
      END IF
      ELSE
      IF (ET.LT.EPLAST) THEN
      ELAST=EC
      SIG=SIG+ELAST*ES
      IF (SIG.LT.SCV.AND.ICSTR.EQ.0) THEN
      SIG=SCV
      ELAST=ECV
      END IF
      IF (SIG.GT.0) SIG=0
      ELSE
      SIG=0
      ELAST=0
      END IF
      END IF
      IF (ICSTR.EQ.1) THEN
      IF (SIG.LT.1.AND.SIG.GT.-1) SIG=0
      END IF
      RETURN
      END
C*****************************************************************

      SUBROUTINE HOGNES(E,EPS,WHICH,SIG,ELAST,FACT)
C*****************************************************************
      IMPLICIT REAL*8 (A-H,O-Z)
      DIMENSION E(4,6)
      S11=0.85*E(WHICH,2)*FACT
      EO=E(WHICH,1)*DSQRT(FACT)
      EPC=2*S11/EC
      EU=E(WHICH,6)
      IF (EPS.GE.0) THEN
      SIG=EO*EPS
      ELAST=EO
      ELSE
      IF (DABS(EPS).LE.EPC) THEN
      RAT=DABS(EPS)/EPO
      SIG=-S11*RAT*(2-RAT)
      ELAST=EC*(1-RAT)
      ELSE
      RAT=(DABS(EPS)-EPO)/(EU-EPC)
      SIG=-S11*(1-0.15*RAT)
      ELAST=(-0.15*S11)/(EU-EPC)
      END IF
      END IF
      RETURN
      END
C*****************************************************************

      SUBROUTINE HOGSTR(E,WHICH,SIG,ELAST,FACT,ES)
C*****************************************************************
      IMPLICIT REAL*8 (A-H,O-Z)
      DIMENSION E(4,6)
      S11=0.85*E(WHICH,2)
      EO=E(WHICH,1)
      EU=E(WHICH,6)
      EPC=2*S11/EO
      IF (DABS(SIG).GT.S11) SIG=-S11
      IF (ELAST.GT.0) THEN
      ELAST=EC*DSQRT(1+SIG/S11)*DSQRT(FACT)
      GO TO 100
      END IF
      IF (ELAST.EQ.0.AND.ES.LT.0) THEN
      ELAST=(-0.15*S11)/(EU-EPC)
      SIG=SIG+ELAST*ES
      GO TO 100
      END IF
      IF (ELAST.LT.0) ELAST=(-0.15*S11)/(EU-EPO)
  100 CONTINUE
      RETURN
      END
C*****************************************************************

      SUBROUTINE BILINR(E,EPS,WHICH,SIG,ELAST,FACT)
C*****************************************************************
      IMPLICIT REAL*8 (A-H,O-Z)
      DIMENSION E(4,6)
      EO=E(WHICH,1)*DSQRT(FACT)
      FC1=E(WHICH,2)*FACT
      EPC=-FC1/EO
      IF (EPS.GE.EPC) THEN
      SIG=EO*EPS
      ELAST=EO
      ELSE
      SIG=-FC1
      ELAST=0
      END IF
      RETURN
      END
C*****************************************************************

      SUBROUTINE RSTEEL(E,ET,ES,SIG,ELAST,YLD,WHICH,FINISH,NWSTP)
C*****************************************************************
```

```
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION E(4,6)
      SY=E(WHICH,1)*E(WHICH,2)
      EO=E(WHICH,1)
      EU=E(WHICH,6)
      IF(DABS(ET).GE.EU) FINISH=3
      IF(DABS(SIG).LT.SY)THEN
      SIG=SIG+EO*ES
      ELAST=EO
      ELSE
      IF(NWSTP.EQ.1) THEN
      SIGNAL=SIG/DABS(SIG)
      IF(SIGNAL*ES.LT.0) THEN
      SIG=SY+EO*ES
      ELAST=0
      END IF
      END IF
      END IF
      IF(DABS(SIG).GE.SY)THEN
      SIGNAL=SIG/DABS(SIG)
      SIG=SIGNAL*SY
      ELAST=0
      YLD=0
      END IF
      RETURN
      END
C*************************************************************
      SUBROUTINE ACRACK(NEL,AREA,STA,NS1,NS3,EALL,DIM,IATYPE,IGMAT,
     *           NGL,NL,IEL,ICOMP,ICRACK,IALPHA,ERG,ERD,Y,ICSTR)
C*************************************************************
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION AREA(NEL,8),STA(NEL,NS1),DIM(NEL,8),IEL(NEL,3),
     *          Y(NL,3),ICRACK(NEL,NL),IALPHA(NEL,NL),EALL(NEL,NS3)
      DO 10 NE=1,NEL
      ITYPE=IEL(NE,3)
      IF(ITYPE.EQ.0) THEN
      CMI=(AREA(NE,4)-AREA(NE,2)*AREA(NE,1)**2)
      IF(CMI.GT.0.00001.AND.STA(NE,NS1).GT.1.E-15)THEN
      CGAMA=STA(NE,NS1)*AREA(NE,8)/CMI
      ELSE
      CGAMA=C
      END IF
      END IF
      CALL LAYER(DIM,ICOMP,IATYPE,IGMAT,ITYPE,NEL,NE,Y,TH,NGL,NL)
      IF(ITYPE.EQ.0) THEN
      SG=0
      IF(ICOMP.EQ.0) LIM=NGL
      IF(ICOMP.EQ.1) LIM=NL
      DO 20 JL=1,LIM
      L=LIM+1-JL
      STAN=STA(NE,L)
      IF(STA(NE,L).LT.1.E-15) STAN=0
      SG=SG+Y(L,2)*(Y(L,1)-AREA(NE,1))
      IF(ICRACK(NE,L).EQ.0)GO TO 20
      IF(IGMAT.EQ.0) THEN
      IF(L.LE.NGL)GO TO 20
      END IF
      V=0.2
      IF(EALL(NE,L).LE.0)THEN
      GXY=0
      ELSE
      GXY=CGAMA*SG*2*(1+V)/(Y(L,3)*EALL(NE,L))
      END IF
      RAD=STAN**2+GXY**2
      A=STAN
      SQ=DSQRT(RAD)
      EP=(A+SQ)/2
      IF(L.LE.NGL) ER=ERG
      IF(L.GT.NGL) ER=ERD
      IF(EP.GE.ER) THEN
      IF(STA(NE,L).GT.0) THEN
      IF(ICSTR.EQ.0) ICRACK(NE,L)=0
      B=GXY/(STAN*(1+V))
      IALPHA(NE,L)=DATAN(B)*180/(2*3.141592654)
      ELSE
      ICRACK(NE,L)=-1
      END IF
      END IF
   20 CONTINUE
      ELSE
      LIM=NGL+1
      DO 30 L=LIM,NL
      IF(STA(NE,L).GE.ERD.AND.ICSTR.EQ.0)ICRACK(NE,L)=0
   30 CONTINUE
      END IF
   10 CONTINUE
      RETURN
      END
C*************************************************************
      SUBROUTINE CRACKS(STRB,DIM,NEL,IGMAT,CRACK,ERG,ERD,ICOMP,X,
     *                  IEL,NNOD,ICRACK,NGL,NL)
C*************************************************************
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION STRB(NEL,8),DIM(NEL,6),CRACK(NEL,8),CRAST(8),
     *          X(NNOD,2),IEL(NEL,3),ICRACK(NEL,NL)
      DO 10 I=1,NEL
      N1=IEL(I,1)
      N2=IEL(I,2)
      AL=X(N2,1)-X(N1,1)
      DO 6 J=1,8
      CRAST(J)=0
    6 CONTINUE
      IF(IGMAT.EQ.0) GO TO 100
      HG=DIM(I,4)+DIM(I,6)+DIM(I,8)
      IF(STRB(I,1).GE.ERG.AND.ICRACK(I,1).EQ.0)THEN
C     IF(STRB(I,2).GE.ERG) THEN
C     WRITE(3,1000)
C1000 FORMAT(//,5('*****GIRDER FAILURE*****'),//)
C     END IF
      CRAST(1)=(STRB(I,1)-ERG)*HG/(STRB(I,1)-STRB(I,2))
      CRAST(5)=(STRB(I,1)-ERG)*AL
      END IF
      IF(STRB(I,2).GE.ERG.AND.ICRACK(I,NGL).EQ.0)THEN
      CRAST(2)=(STRB(I,2)-ERG)*HG/(STRB(I,2)-STRB(I,1))
      CRAST(6)=(STRB(I,2)-ERG)*AL
      END IF
  100 IF(ICOMP.EQ.1) THEN
      HD=DIM(I,2)
```

```
      IF(STRB(I,3).GE.ERD.AND.ICRACK(I,NGL+1).EQ.0)THEN
C     IF(STRB(I,4).GE.ERD) THEN
C     WRITE(3,2000)
C2000 FORMAT(//,5('*****DECK FAILURE*****'),//)
C     END IF
      CRAST(3)=(STRB(I,3)-ERD)*HD/(STRB(I,3)-STRB(I,4))
      CRAST(7)=(STRB(I,3)-ERD)*AL
      END IF
      IF(STRB(I,4).GE.ERD.AND.ICRACK(I,NL).EQ.0)THEN
      CRAST(4)=(STRB(I,4)-ERD)*HD/(STRB(I,4)-STRB(I,3))
      CRAST(8)=(STRB(I,4)-ERD)*AL
      END IF
      END IF
      DO 20 K=1,8
      IF(CRAST(K).GT.CRACK(I,K)) CRACK(I,K)=CRAST(K)
   20 CONTINUE
   10 CONTINUE
      RETURN
      END
C***************************************************************

      SUBROUTINE PROTEN(YCABLE,CLOAD,X,CABLE,IEL,NEL,NNOD,NOWPRO,
     *                  NPS,PSEGM,ELONG,FM,FK,E,FINCAB)
C***************************************************************
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION YCABLE(NNOD),CLOAD(NNOD,3),X(NNOD,2),CABLE(NEL,7),
     *     FINCAB(NEL,3),IEL(NEL,3),PSEGM(10,5),ELONG(10,2),E(4,6)
      IF(NOWPRO.EQ.1)GO TO 1000
      DO 40 I=1,NPS
      NE1=PSEGM(I,1)
      NE2=PSEGM(I,2)
      DO 45 J=NE1,NE2
      CABLE(J,3)=PSEGM(I,4)
      CABLE(J,4)=PSEGM(I,3)
      CABLE(J,7)=E(1,1)
   45 CONTINUE
   40 CONTINUE
      DO 10 I=1,NEL
      IF(IEL(I,3).EQ.1)GO TO 10
      N1=IEL(I,1)
      N2=IEL(I,2)
      EL=X(N2,1)-X(N1,1)
      ALPHA=(YCABLE(N1)-YCABLE(N2))/EL
      ACOS=DCOS(ALPHA)
      CABLE(I,1)=ALPHA
      CABLE(I,2)=EL/ACOS
      CABLE(I,5)=CABLE(I,3)/CABLE(I,4)
      SIG=CABLE(I,5)
      EPS=CABLE(I,6)
      EMOD=CABLE(I,7)
      CALL FINDEE(E,SIG,EPS,EMOD)
      CABLE(I,6)=EPS
      CABLE(I,7)=EMOD
   10 CONTINUE
      DO 50 I=1,NPS
      NE1=PSEGM(I,1)
      NE2=PSEGM(I,2)
      ELONG(I,1)=0
      ELONG(I,2)=0
      DO 55 J=NE1,NE2
      ELONG(I,1)=ELONG(I,1)+CABLE(J,2)
   55 CONTINUE
      ELONG(I,2)=(PSEGM(I,4)*ELONG(I,1))/(CABLE(NE1,7)*PSEGM(I,3))
   50 CONTINUE
      FRICT=FM+FK
      IF(FRICT.NE.0) THEN
      CALL FRLOSS(CABLE,NEL,NPS,PSEGM,FM,FK,ELONG,E)
      END IF
      DO 20 I=1,NEL
      FINCAB(I,1)=CABLE(I,3)
   20 CONTINUE
 1000 DO 30 I=1,NEL
      IF(IEL(I,3).EQ.1)GO TO 30
      N1=IEL(I,1)
      N2=IEL(I,2)
      ALPHA=CABLE(I,1)
      ACOS=DCOS(ALPHA)
      ASIN=DSIN(ALPHA)
      F=CABLE(I,3)
      Y1=YCABLE(N1)+X(N1,2)
      Y2=YCABLE(N2)+X(N2,2)
      CLOAD(N1,1)=CLOAD(N1,1)+F*ACOS
      CLOAD(N1,2)=CLOAD(N1,2)-F*ASIN
      CLOAD(N1,3)=CLOAD(N1,3)-Y1*F*ACOS
      CLOAD(N2,1)=CLOAD(N2,1)-F*ACOS
      CLOAD(N2,2)=CLOAD(N2,2)+F*ASIN
      CLOAD(N2,3)=CLOAD(N2,3)+Y2*F*ACOS
   30 CONTINUE
      RETURN
      END
C***************************************************************

      SUBROUTINE MODCAB(CABLE,YCABLE,B,NEL,IEL,NVAR,X,NNOD,E,CABSST,
     *                  NWSTP,NODE3)
C***************************************************************
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION CABLE(NEL,7),DISP(6),YCABLE(NNOD),B(1),
     * CABSST(NEL),NVAR(NNOD,3),X(NNOD,2),IEL(NEL,3),E(4,6)
      DO 500 I=1,NEL
      IF(IEL(I,3).EQ.1)GO TO 500
      DO 510 J=1,3
      NN1=IEL(I,1)
      JA=NVAR(NN1,J)
      IF(JA.EQ.0)THEN
      DISP(J)=0
      ELSE
      DISP(J)=B(JA)
      END IF
      NN2=IEL(I,2)
      J3=J+3
      JA=NVAR(NN2,J)
      IF(JA.EQ.0)THEN
      DISP(J3)=0
      ELSE
      DISP(J3)=B(JA)
      END IF
  510 CONTINUE
      ALPHA=CABLE(I,1)
      ACOS=DCOS(ALPHA)
      ASIN=DSIN(ALPHA)
```

```
      Y1=YCABLE(NN1)+X(NN1,2)
      Y2=YCABLE(NN2)+X(NN2,2)
      IF(CABLE(I,4).EQ.0)THEN
      STRAIN=0
      ELSE
      STRAIN=(-DISP(1)*ACOS+DISP(2)*ASIN
     +       +DISP(3)*Y1*ACOS+DISP(4)*ACOS
     +       -DISP(5)*ASIN-DISP(6)*Y2*ACOS)/CABLE(I,2)
      END IF
      CABSST(I)=STRAIN
      CABLE(I,6)=CABLE(I,6)+STRAIN
      ET=CABLE(I,6)
      STE=CABLE(I,5)
      ELAST=CABLE(I,7)
      CALL PSTEEL(E,ET,STRAIN,STE,ELAST,NWSTP)
      CABLE(I,5)=STE
      CABLE(I,7)=ELAST
      CABLE(I,3)=CABLE(I,5)*CABLE(I,4)
  500 CONTINUE
      RETURN
      END
C*****************************************************************

      SUBROUTINE FRLOSS(CABLE,NEL,NPS,PSEGM,FM,FK,ELONG,E)
C*****************************************************************
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION CABLE(NEL,7),PSEGM(10,5),ELONG(10,2),E(4,6)
      DO 10 I=1,NPS
      IELEM=PSEGM(I,1)
      LELEM=PSEGM(I,2)
      F2=0
      ELONG(I,2)=0
      DO 20 L=IELEM,LELEM
      J=L
      JA=J-1
      JP=J+1
      IF(PSEGM(I,5).EQ.2)THEN
      J=IELEM+LELEM-L
      JA=J+1
      JP=J-1
      END IF
      F1=F2
      IF(L.EQ.IELEM)THEN
      F1=CABLE(J,3)
      TIJ=0
      GO TO 1
      END IF
      A=CABLE(JA,1)-CABLE(J,1)
      T=DABS(A)
      TIJ=T*CABLE(J,2)/(CABLE(JA,2)+CABLE(J,2))
    1 IF(L.EQ.LELEM)THEN
      TJK=0
      GO TO 2
      END IF
      A=CABLE(J,1)-CABLE(JP,1)
      T=DABS(A)
      TJK=T*CABLE(J,2)/(CABLE(L,2)+CABLE(JP,2))
    2 TJ=TIJ+TJK
      CL=CABLE(J,2)
      F2=F1/2.71828**(FM*TJ+FK*CL)
```

```
      CABLE(J,3)=(F1+F2)/2
      CABLE(J,5)=CABLE(J,3)/CABLE(J,4)
      SIG=CABLE(J,5)
      EPS=CABLE(J,6)
      EMOD=CABLE(J,7)
      CALL FINDEE(E,SIG,EPS,EMOD)
      CABLE(J,6)=EPS
      CABLE(J,7)=EMOD
      ELONG(I,2)=ELONG(I,2)+CABLE(J,6)*CABLE(J,2)
   20 CONTINUE
   10 CONTINUE
      RETURN
      END
C*****************************************************************

      SUBROUTINE PSTEEL(E,ET,ES,STRE,ELAST,NWSTP)
C*****************************************************************
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION E(4,6)
      IF(NWSTP.EQ.0)GO TO 100
      IF(ES.LT.0)THEN
      STRE=STRE+E(1,1)*ES
      ELAST=E(1,1)
      ELSE
  100 STRE=STRE+ELAST*ES
      SIG=0
      EMOD=0
      CALL FINDSE(E,ET,SIG,EMOD)
      IF(STRE.GT.SIG)THEN
      STRE=SIG
      ELAST=EMOD
      END IF
      END IF
      RETURN
      END
C*****************************************************************

      SUBROUTINE FINDSE(E,EPS,SIG,EMOD)
C*****************************************************************
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION E(4,6)
      E0=E(1,1)
      E1=E(1,2)
      E2=E(1,3)
      SY1=E(1,4)
      SY2=E(1,5)
      EY1=SY1/E0
      EY2=EY1+(SY2-SY1)/E1
      EU=E(1,6)
      IF(EPS.GE.EU)THEN
      WRITE(3,1)
    1 FORMAT('*** PRESTRESSING CABLE RUPTURE ***')
      END IF
      IF(EPS.GT.EY2)THEN
      EMOD=E2
      SIG=SY2+(EPS-EY2)*E2
      ELSE
      IF(EPS.GT.EY1)THEN
      EMOD=E1
      SIG=SY1+(EPS-EY1)*E1
```

```
      ELSE
      EMCD=EC
      SIG=EPS*EO
      END IF
      END IF
      RETURN
      END
C***************************************************************
      SUBROUTINE FINDEE(E,SIG,EPS,EMCD)
C***************************************************************
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION E(4,6)
      EO=E(1,1)
      E1=E(1,2)
      E2=E(1,3)
      SY1=E(1,4)
      SY2=E(1,5)
      EY1=SY1/EO
      EY2=EY1+(SY2-SY1)/E1
      EU=E(1,6)
      IF(SIG.GT.SY2) THEN
      EMCD=E2
      EPS=EY2+(SIG-SY2)/E2
      ELSE
      IF(SIG.GT.SY1) THEN
      EMCD=E1
      EPS=EY1+(SIG-SY1)/E1
      ELSE
      EMCD=EC
      EPS=SIG/EO
      END IF
      END IF
      IF(EPS.GE.EU) THEN
      WRITE(3,1)
    1 FORMAT('*** PRESTRESSING CABLE RUPTURE ***')
      END IF
      RETURN
      END
C***************************************************************
      SUBROUTINE REACT(NSUP,NNOD,NVAR,REAC,PREDIS,ITNST,RELIST,DCL)
C***************************************************************
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION REAC(NSUP,3),RELIST(300,10)
     + ,NVAR(NNOD,3),PREDIS(NSUP,2),DCL(NNOD,3)
      NR=0
      DO 10 NS=1,NSUP
      NN=PREDIS(NS,1)
      DO 50 I=1,3
      REAC(NS,I)=DCL(NN,I)
C
C                              STORE ALL REACTIONS
      IF(NVAR(NN,I).EQ.0)THEN
      NR=NR+1
      RELIST(ITNST,NR)=REAC(NS,I)
      END IF
   50 CONTINUE
   10 CONTINUE
      RETURN
      END
C***************************************************************
      SUBROUTINE OUTPUT(NEL,ICOMP,AREA,NNOD,NVAR,FORCE,SDISP,
     +                  IGMAT,CABLE,NONPRO,FM,FK,KPS,PSEGM,ELONG,
     +            ICHECK,NCHEL,IATYPE,DIM,NGL,NL,STA,NS1,STRE,NS3,
     +                  EALL,STRB,ERG,ERD,CRACK,ICRACK,IALPHA,
     +                  IELD,NS4,IEL,Y,NSUP,NSUP3,REAC,PREDIS,
     +                  DISP,ISTEP,LC,NSTEPS,ITER,NTITER)
C***************************************************************
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION AREA(NEL,8),NVAR(NNOD,3),DISP(NNOD,3),SDISP(NNOD,3)
     +         ,CABLE(NEL,7),PSEGM(10,5),ELONG(10,2),
     +          ICHECK(NCHEL),DIM(NEL,8),Y(NL,3),STA(NEL,NS1),
     +          STRE(NEL,NS3),EALL(NEL,NS3),STRB(NEL,8),CRACK(NEL,8),
     +          ICRACK(NEL,NL),IALPHA(NEL,NL),IELD(NEL,NS4),IEL(NEL,3)
     +         ,REAC(NSUP,3),PREDIS(NSUP,2),FORCE(NEL,3)
C
      WRITE(3,2222)
      WRITE(3,2001)LC,ISTEP,NSTEPS,ITER,NTITER
 2001 FORMAT(10X,'L O A D   C A S E  #',I3,10X,'STEP #',I3,'/',I3,
     +       10X,'ITER. IN THE STEP= ',I3,10X,'TOTAL # ITER.= ',I5)
C
      WRITE(3,2222)
 2222 FORMAT(/,130('*'),/)
      WRITE(3,29)
   29 FORMAT(10X,'N E W  S E C T I O N  P R O P E R T I E S',
     + 10X,'( TRANSFORMED, TO BOTTOM )',/)
      IF(ICOMP.EQ.1) THEN
      WRITE(3,32)
   32 FORMAT(/,20X,'( COMPOSITE SECTION )')
      ELSE
      WRITE(3,33)
   33 FORMAT(/,20X,'( NON COMPOSITE SECTION )')
      END IF
      WRITE(3,1111)
 1111 FORMAT(/,130('-'),/)
      WRITE(3,31)
   31 FORMAT(1X,'ELEM #',4X,'CENTROID',10X,'AREA',9X,'AREA MOM.',
     +       7X,'INERTIA',//)
      DO 41 I=1,NEL
      WRITE(3,50)I,(AREA(I,J),J=1,4)
   50 FORMAT(4X,I3,4(2X,D13.6),/)
   41 CONTINUE
C
      WRITE(3,2222)
      WRITE(3,1650)
 1650 FORMAT(/,10X,'N O D A L  D I S P L A C E M E N T S (+)R,UP,CC',
     +       //,30X,'( THIS STEP )',45X,'( TOTAL )')
      WRITE(3,1111)
      WRITE(3,1670)
 1670 FORMAT(1X,'NODE #',10X,'X',18X,'Y',15X,'THETA',
     +       15X,'X',18X,'Y',15X,'THETA',///)
      DO 200 I=1,NNOD
      WRITE(3,1700)I,DISP(I,1),DISP(I,2),DISP(I,3)
     +             ,SDISP(I,1),SDISP(I,2),SDISP(I,3)
 1700 FORMAT(4X,I3,6(5X,D13.6),/)
  200 CONTINUE
C
      WRITE(3,2222)
```

```
      WRITE(3,1000)
 1000 FORMAT(10X,'E L E M E N T   R E S U L T A N T   F O R C E S',
     +       5X,'(+) TENSION,COMP.UP,LEFT UP',//
     +       30X,'( TOTAL )')
      WRITE(3,1111)
      WRITE(3,1100)
 1100 FORMAT(1X,'ELEM #',9X,'AXIAL',12X,'MOMENT',13X,'SHEAR',//)
      DO 1200 I=1,NEL
      WRITE(3,1300)I,(FORCE(I,J),J=1,3)
 1300 FORMAT(4X,I3,3(5X,D13.6),/)
 1200 CONTINUE
C
      WRITE(3,2222)
      WRITE(3,7000)
 7000 FORMAT(/,10X,'N O D A L   E X T E R N A L   R E A C T I O N S
     +       (+)R,UP,CC',//,30X,'( TOTAL )')
      WRITE(3,1111)
      WRITE(3,7010)
 7010 FORMAT(1X,'NODE #',11X,'RX',15X,'RY',16X,'MZ',//)
      DO 7030 J=1,NSUP
      I=PREDIS(J,1)
      WRITE(3,7020)I,(REAC(J,K),K=1,3)
 7020 FORMAT(4X,I3,3(5X,D13.6),/)
 7030 CONTINUE
C
      IF(IGMAT.EQ.1) THEN
      WRITE(3,2222)
      WRITE(3,2100)
 2100 FORMAT(10X,'F I N A L   C A B L E   P R O P E R T I E S ',
     +       '  ( UP TO THIS STEP )  ')
      WRITE(3,1111)
      WRITE(3,2200)
 2200 FORMAT(1X,'ELEM #',6X,'FORCE',8X,'STRESS',8X,'STRAIN',
     +       8X,' E MOD',//)
      DO 700 K=1,NEL
      WRITE(3,2300)K,CABLE(K,3),CABLE(K,5),CABLE(K,6),CABLE(K,7)
 2300 FORMAT(4X,I3,4(2X,D12.5),/)
  700 CONTINUE
      END IF
C
      IF(NCMFRO.EQ.1) THEN
      WRITE(3,2222)
      WRITE(3,2400)
 2400 FORMAT(10X,'CABLE ELONGATION BY PRESTRESSING',
     +       '  ( FRICTION INCLUDED )')
      WRITE(3,1111)
      WRITE(3,2450)FM
 2450 FORMAT(1X,'CURVATURE FRICTION COEFFICIENT =',2X,D12.5,/)
      WRITE(3,2451)FK
 2451 FORMAT(1X,'WOBBLE FRICTION CEFFICIENT     =',2X,D12.5,/)
      WRITE(3,1111)
      WRITE(3,2452)
 2452 FORMAT(1X,'FROM ELEM #  TO  ELEM #',7X,'LENGHT',7X,
     +       'ELONGATION',//)
      DO 800 K=1,NPS
      NE1=PSEGM(K,1)
      NE2=PSEGM(K,2)
      WRITE(3,2600)NE1,NE2,ELONG(K,1),ELONG(K,2)
 2600 FORMAT(9X,I3,9X,I3,4X,D12.5,3X,D12.5,/)
  800 CONTINUE
```

```
      END IF
C
      WRITE(3,2222)
      WRITE(3,2510)
 2510 FORMAT(30X,'S T R A I N S  A T  T H E  B O R D E R S ',
     +       ///,30X,'( UP TO THIS STEP )',41X,'( MAX. REACHED )')
      WRITE(3,1111)
      WRITE(3,2511)
 2511 FORMAT(1X,'ELEM #',2X,'BOTTOM GIRDER',2X,' TOP  GIRDER ',
     +                      2X,' BOTTOM DECK ',2X,'  TOP  DECK  ',
     +                      2X,'BOTTOM GIRDER',2X,' TOP  GIRDER ',
     +                      2X,' BOTTOM DECK ',2X,'  TOP  DECK  ',//)
      DO 2520 K=1,NEL
      WRITE(3,2521)K,(STRD(K,J),J=1,8)
 2521 FORMAT(4X,I3,8(2X,D13.6),/)
 2520 CONTINUE
C
      WRITE(3,2222)
      WRITE(3,3000)
 3000 FORMAT(30X,' C R A C K I N G   LENGTH  &  WIDTH')
      WRITE(3,1111)
      WRITE(3,4000)ERG,ERD
 4000 FORMAT(1X,'GIRDER RUPTURE STRAIN =',D12.5,//,
     +       1X,' DECK  RUPTURE STRAIN =',D12.5)
      WRITE(3,1111)
      WRITE(3,5000)
 5000 FORMAT(1X,'ELEM #',2X,'BOTTOM GIRDER',
     +                      2X,'  TOP  GIRDER',
     +                      2X,' BOTTOM  DECK',
     +                      2X,'  TOP   DECK ',
     +                      2X,'BOTTOM GIRDER',
     +                      2X,'  TOP  GIRDER',
     +                      2X,' BOTTOM  DECK',
     +                      2X,'  TOP   DECK ',//)
      DO 30 I=1,NEL
      WRITE(3,6000)I,(CRACK(I,J),J=1,8)
 6000 FORMAT(4X,I3,8(2X,D13.6),/)
   30 CONTINUE
C
      WRITE(3,2222)
      WRITE(3,3100)
 3100 FORMAT(30X,'C R A C K I N G    P A T T E R N ')
      WRITE(3,1111)
      WRITE(3,3400)ERG,ERD
 3400 FORMAT(1X,'GIRDER RUPTURE STRAIN =',D12.5,//,
     +       1X,' DECK  RUPTURE STRAIN =',D12.5)
      WRITE(3,1111)
      WRITE(3,3500)
 3500 FORMAT(1X,'ELEM #',20X,'L A Y E R S',//)
      IF(ICOMP.EQ.0) LIM=NGL
      IF(ICOMP.EQ.1) LIM=NL
      DO 35 I=1,NEL
      WRITE(3,3600)I,(ICRACK(I,J),J=1,LIM)
 3600 FORMAT(4X,I3,5X,40(I2),/)
   35 CONTINUE
      WRITE(3,1111)
      WRITE(3,3800)
 3800 FORMAT(20X,'C R A C K   A N G L E S  ( DEGREES )')
      WRITE(3,1111)
      DO 60 I=1,NEL
```

```
      WRITE(3,3900)I,(IALPHA(I,J),J=1,LIM)
 3900 FORMAT(4X,I3,3X,40(I3),/)
   60 CONTINUE
C
      WRITE(3,2222)
      WRITE(3,5004)
 5004 FORMAT(10X,'R E I N F.  S T E E L   S T R E S S E S ')
      WRITE(3,1111)
      WRITE(3,5001)
 5001 FORMAT(1X,'ELEM #',4X,'DECK STEEL',5X,'TOP  STEEL',
     *                    4X,'BOTTOM STEEL',//)
      DO 5002 I=1,NEL
      WRITE(3,5003)I,(STRE(I,NL+J),J=1,3)
 5003 FORMAT(4X,I3,3(3X,D12.5),/)
 5002 CONTINUE
C
      WRITE(3,2222)
      WRITE(3,1050)
 1050 FORMAT(30X,'Y I E L D I N G    ( NGL+3 )')
      WRITE(3,1111)
      WRITE(3,1150)
 1150 FORMAT(1X,'ELEM #',15X,'REINF.STEEL ( D,T,B )  &  L A Y E R S',//)
      LIM=NGL+1
      DO 1250 I=1,NEL
      WRITE(3,1350)I,(IELD(I,J),J=LIM,NS4),(IELD(I,J),J=1,NGL)
 1350 FORMAT(4X,I3,5X,3(I2),2X,40(I2),/)
 1250 CONTINUE
C
      IF(NCHEL.GT.0)THEN
      WRITE(3,2222)
      WRITE(3,3005)
 3005 FORMAT(20X,'C H E C K I N G   E L E M E N T S ')
      DO 3010 NK=1,NCHEL
      WRITE(3,1111)
      NEC=ICHECK(NK)
      WRITE(3,3020)NEC
 3020 FORMAT(20X,'ELEMENT #',2X,I3,/)
      WRITE(3,1111)
      WRITE(3,3030)
 3030 FORMAT(4X,'#',7X,'POSITION',6X,'LAYER AREA',8X,'STRAIN',12X,
     *           'STRESS',9X,'INST.MODULUS',//)
      ITYPE=IEL(NEC,3)
      CALL LAYER(DIM,ICOMP,IATYPE,IGMAT,ITYPE,NEL,NEC,Y,TH,NGL,NL)
      DO 3040 J=1,NL
      L=NL+1-J
      WRITE(3,3050)L,Y(L,1),Y(L,2),STA(NEC,L),STRE(NEC,L),EALL(NEC,L)
 3050 FORMAT(3X,I2,5X,D12.5,3X,D12.5,3(3X,D15.8),/)
 3040 CONTINUE
 3010 CONTINUE
      END IF
      WRITE(3,2222)
      RETURN
      END
C**************************************************************
C  DATA INPUT                                                 *
C**************************************************************
C                                                             *
C  # OF EXEMPLES TO BE RUN                                    *
C  NEL,NCEL,NNOD,NSUP,NLOCA,NGL(S/6,I/4,R/6),NDL,NCHEL        *
C  LIST ELEM.S TO BE CHECKED, IF ANY                          *
C  BEARING COEFFICIENT                                        *
C  DRIVLI,NOER,ALPLL                                          *
C  IGMAT, IATYPE, ICONST, ISTEEL, ISSC                        *
C  GAMAG,GAMAD                                                *
C  TIMES: TGC,TDC,TGFL,TDFL,TP  (ALL >= 28 DAYS )             *
C  MATERIAL PROPERTIES : (ALL POSITIVE )                      *
C     P/S :   EO,  E1,  E2, SY1, SY2, EU                      *
C     R/S :   EO,  EY,   0,   0,   0, EU                      *
C     G/S :   EO,  EY,   0,   0,   0, EU                      *
C  OR                                                         *
C     G/C :   EO, FC1,  ER,   0,   0, EU                      *
C     D/C :   EO, FC1,  ER,   0,   0, EU                      *
C  IEL :  NODE 1, NODE 2 ,TYPE 0 OR 1                         *
C  ...    ALL ELEMENTS   ...                                  *
C  COORD X,Y ,NODE COND 0 OR 1 IN X,Y,Z                       *
C  ...    ALL NODES    ...                                    *
C  DIMENTIONS:             STEEL GIRDER                       *
C                    BD, HD,  A,  H,  M, T1, WT, BT           *
C                          RECT. GIRDER                       *
C                    BD, HD,  B,  H,  0,  0,  0,  0           *
C                          OTHER SHAPE                        *
C                    BD, HD, BT, HT, DW, HW, BD, HB           *
C                          CONECTION ELEMENT                  *
C                    BD, HD, H1, H2,  0,  0,  0,  0           *
C     ... ONE LINE IF CONSTANT CROSS SECTION                  *
C          ALL ELEMENTS IF VARIABLE               ...         *
C  STEEL:                  STEEL GIRDER OR CONECTION ELEMENT  *
C                    DSA, DSP,   0,   0,   0,   0             *
C                          CONCRETE GIRDER                    *
C                    DSA, DSP, TSA, TSP, BSA, BSP             *
C     ... ONE LINE IF CONSTANT                                *
C          ALL ELEMENTS IF VARIABLE...                        *
C  L.C.#,ICOMP,# STEPS,PRINT,EFFECT,I.TIME,F.TIME,HINGED      *
C  ...    ALL   ...                                           *
C  NODE #, PRESCRIBED DISPLACEMENT                            *
C  ...    ALL SUPPORTS   ...                                  *
C  TEMP. VAR. :  T1 , T2 , T3                                 *
C  APPLIED NODAL LOADS : X Y M                                *
C  ...    ALL NODES  ...                                      *
C  APPLIED ELEM. LOADS : Q, P, AP                             *
C  ...    ALL ELEMENTS   ...                                  *
C                               PRESTRESSING  ( IF USED )     *
C  IPRET,IFROF,NPS,FM,FR,IST                                  *
C  ELEM# TO ELEM#,AREA,FO,IPULL                               *
C  ...    ALL SEGMENTS   ...                                  *
C  NODE,POS,NODE,POS,NODE,POS                                 *
C  ...    ALL SEGMENTS   ...                                  *
C  OR                                                         *
C  CABLE POSITION                                             *
C  ...    ALL NODES   ...                                     *
C                                                             *
C**************************************************************
```

8.3 Sample Input

Input for the deck-continuous beam shown in Figs. 5.16 and 5.17 and loaded as in Fig. 5.23.

```
1
24, 2, 25, 5, 4, 20, 10, 2
6, 18
23000
-0.05, 6, 5
1, 1, 0, 1, 1
0.0868, 0.0868
0, 0, 0, 0, 0
28000000, 3100000, 120000, 240000, 260000, 0.1
29000000, 0.001724, 0, 0, 0, 0.01
4500000, 6000, 0.00013, 0, 0, 0.003
3500000, 3500, 0.00013, 0, 0, 0.003
1, 2, 0
2, 3, 0
3, 4, 0
4, 5, 0
5, 6, 0
6, 7, 0
7, 8, 0
8, 9, 0
9, 10, 0
10, 11, 0
11, 12, 0
12, 13, 1
13, 14, 0
14, 15, 0
15, 16, 0
16, 17, 0
17, 18, 0
18, 19, 0
19, 20, 0
20, 21, 0
21, 22, 0
22, 23, 0
23, 24, 0
24, 25, 1
0, 0, 0, 1, 0
72, 0, 0, 0, 0
144, 0, 0, 0, 0
216, 0, 0, 0, 0
288, 0, 0, 0, 0
360, 0, 0, 0, 0
432, 0, 0, 0, 0
504, 0, 0, 0, 0
576, 0, 0, 0, 0
648, 0, 0, 0, 0
720, 0, 0, 0, 0
786, 0, 0, 1, 0
798, 0, 0, 1, 0
864, 0, 0, 0, 0
936, 0, 0, 0, 0
1008, 0, 0, 0, 0
1080, 0, 0, 0, 0
1152, 0, 0, 0, 0
1224, 0, 0, 0, 0
1296, 0, 0, 0, 0
1368, 0, 0, 0, 0
1440, 0, 0, 0, 0
1512, 0, 0, 0, 0
1578, 0, 0, 1, 0
1584, 0, 1, 1, 1
72, 6, 20, 11, 8, 30, 26, 13
6.75, 57, 0, 0, 0, 0
6.75, 57, 0, 0, 0, 0
6.75, 57, 0, 0, 0, 0
6.75, 57, 0, 0, 0, 0
6.75, 57, 0, 0, 0, 0
6.75, 57, 0, 0, 0, 0
6.75, 57, 0, 0, 0, 0
6.75, 57, 0, 0, 0, 0
6.75, 57, 2, 51, 0, 0
6.75, 57, 2, 51, 0, 0
11.25, 57, 2, 51, 2, 2
11.25, 57, 2, 51, 2, 2
11.25, 57, 2, 51, 2, 2
6.75, 57, 2, 51, 0, 0
6.75, 57, 2, 51, 0, 0
6.75, 57, 0, 0, 0, 0
6.75, 57, 0, 0, 0, 0
6.75, 57, 0, 0, 0, 0
6.75, 57, 0, 0, 0, 0
6.75, 57, 0, 0, 0, 0
6.75, 57, 2, 51, 0, 0
6.75, 57, 2, 51, 0, 0
11.25, 57, 2, 51, 2, 2
11.25, 57, 2, 51, 2, 2
1, 0, 1, 0, 0, 0, 0, 0
2, 0, 1, 0, 0, 0, 0, 0
3, 0, 1, 0, 0, 0, 0, 0
5, 1, 1000, 0, 0, 0, 0, 0
1, 0
12, 0
13, 0
24, 0
25, 0
0, 0, 0
0, 0, 0
0, 0, 0
0, 0, 0
0, 0, 0
0, 0, 0
0, 0, 0
0, 0, 0
0, 0, 0
0, 0, 0
0, 0, 0
0, 0, 0
0, 0, 0
0, 0, 0
0, 0, 0
0, 0, 0
0, 0, 0
0, 0, 0
0, 0, 0
0, 0, 0
0, 0, 0
0, 0, 0
0, 0, 0
0, 0, 0
0, 0, 0
0, 0, 0
1000, 0, 0
1000, 0, 0
1000, 0, 0
1000, 0, 0
1000, 0, 0
1000, 0, 0
1000, 0, 0
1000, 0, 0
1000, 0, 0
1000, 0, 0
1000, 0, 0
1000, 0, 0
0, 0, 0
0, 0, 0
0, 0, 0
0, 0, 0
0, 0, 0
0, 0, 0
0, 0, 0
0, 0, 0
0, 0, 0
0, 0, 0
0, 0, 0
0, 0, 0
1, 0, 2, 0, 0, 0
1, 11, 2.72, 516000, 1
13, 23, 2.72, 516000, 1
1, 3, 6, 3, 12, 3
13, 3, 18, 3, 24, 3
```

8.4 Sample Output

Output for the deck-continuous beam shown in Figs. 5.16 and 5.17 and loaded as in Fig. 5.23.

```
**************************************************************************************************
**************************************************************************************************

                                        EXAMPLE # 1

**************************************************************************************************
STORAGE PROVIDED =      20000
**************************************************************************************************
                                        I N P U T   D A T A
**************************************************************************************************
NUMBER OF ELEMENTS =   24

NUMBER OF CONECTION ELEMENTS =    2

NUMBER OF NODES =   25

NUMBER OF SUPPORTS =    5
**************************************************************************************************
       P R O P E R T I E S

--------------------------------------------------------------------------------------------------
                             0                1                2
GIRDER MATERIAL        STEEL            PREST. CONC      REINF. CONC
GIRDER TYPE            RECTANGULAR      I,T OR BOX
SECTION DIMENTIONS     CONSTANT         VARIABLE
STEEL DISTRIBUTION     CONSTANT         VARIABLE
COMPOSITE SECTION      NON COMP.        COMPOSITE
STRESS-STRAIN CURVE    HOGNESTAD        BILINEAR

--------------------------------------------------------------------------------------------------

SHAPING COEF.=    0.230000 05

GIRDER MAT. UNIT WEIGHT = 0.86800000D-01
DECK MAT. UNIT WEIGHT = 0.86800000D-01

GIRDER MATERIAL= 1
SECTION TYPE= 1
SECTION DIMENTIONS= 0
STEEL DISTRIBUTION= 1
STRESS-STRAIN CURVE= 1

TIME LIST :     GIRDER CASTING       0.0000 00  DAYS
                 " 1ST LOADING       0.0000 00   "
                DECK  CASTING        0.0000 00   "
                 " 1ST LOADING       0.0000 00   "
                  PRESTRESSING       0.0000 00   "
**************************************************************************************************
             M A T E R I A L   P R O P E R T I E S

--------------------------------------------------------------------------------------------------
  P/S : EO, E1, E2, SY1, SY2, EU
  R/S : EO, EY,  0,   0,   0, EU
  G/S : EO, EY,  0,   0,   0, EU
  G/C : EO, FC1, ER,  0,   0, EU
  D/C : EO, FC1, ER,  0,   0, EU
--------------------------------------------------------------------------------------------------
PREST.STEEL:    0.280000 08    0.310000 07    0.120000 06     0.240000 06    0.260000 06    0.100000 0
REINF.STEEL:    0.290000 08    0.172400-02    0.000000 00     0.000000 00    0.000000 00    0.100000-01
GIRDER MAT.:    0.450000 07    0.600000 04    0.130000-03     0.000000 00    0.000000 00    0.300000-02
DECK CONCR.:    0.350000 07    0.350000 04    0.130000-03     0.000000 00    0.000000 00    0.300000-02

**************************************************************************************************
```

E L E M E N T   I N C I D E N C E   &   T Y P E

ELEM #	N1	N2	TYPE
1	1	2	0
2	2	3	0
3	3	4	0
4	4	5	0
5	5	6	0
6	6	7	0
7	7	8	0
8	8	9	0
9	9	10	0
10	10	11	0
11	11	12	0
12	12	13	1
13	13	14	0
14	14	15	0
15	15	16	0
16	16	17	0
17	17	18	0
18	18	19	0
19	19	20	0
20	20	21	0
21	21	22	0
22	22	23	0
23	23	24	0
24	24	25	1

N O D A L   C O O R D I N A T E S

NODE #	X	Y
1	0.000000 00	0.000000 00
2	0.720000 02	0.000000 00
3	0.144000 03	0.000000 00
4	0.216000 03	0.000000 00
5	0.288000 03	0.000000 00
6	0.360000 03	0.000000 00
7	0.432000 03	0.000000 00
8	0.504000 03	0.000000 00
9	0.576000 03	0.000000 00
10	0.648000 03	0.000000 00
11	0.720000 03	0.000000 00
12	0.786000 03	0.000000 00
13	0.798000 03	0.000000 00
14	0.864000 03	0.000000 00
15	0.936000 03	0.000000 00
16	0.100800 04	0.000000 00
17	0.108000 04	0.000000 00
18	0.115200 04	0.000000 00
19	0.122400 04	0.000000 00
20	0.129600 04	0.000000 00
21	0.136800 04	0.000000 00
22	0.144000 04	0.000000 00
23	0.151200 04	0.000000 00
24	0.157800 04	0.000000 00
25	0.158400 04	0.000000 00

S E C T I O N A L   D I M E N T I O N S

ELEM #	DECK WIDTH	DECK THICK.	TOP WIDTH	TOP THICK.	WEB WIDTH	WEB THICK.	BOTTOM WIDTH	BOTTOM THICK.
1	0.7200000 02	0.6000000 01	0.2000000 02	0.1100000 02	0.8000000 01	0.3000000 02	0.2600000 02	0.1300000 02
2	0.7200000 02	0.6000000 01	0.2000000 02	0.1100000 02	0.8000000 01	0.3000000 02	0.2600000 02	0.1300000 02
3	0.7200000 02	0.6000000 01	0.2000000 02	0.1100000 02	0.8000000 01	0.3000000 02	0.2600000 02	0.1300000 02
4	0.7200000 02	0.6000000 01	0.2000000 02	0.1100000 02	0.8000000 01	0.3000000 02	0.2600000 02	0.1300000 02
5	0.7200000 02	0.6000000 01	0.2000000 02	0.1100000 02	0.8000000 01	0.3000000 02	0.2600000 02	0.1300000 02
6	0.7200000 02	0.6000000 01	0.2000000 02	0.1100000 02	0.8000000 01	0.3000000 02	0.2600000 02	0.1300000 02
7	0.7200000 02	0.6000000 01	0.2000000 02	0.1100000 02	0.8000000 01	0.3000000 02	0.2600000 02	0.1300000 02
8	0.7200000 02	0.6000000 01	0.2000000 02	0.1100000 02	0.8000000 01	0.3000000 02	0.2600000 02	0.1300000 02
9	0.7200000 02	0.6000000 01	0.2000000 02	0.1100000 02	0.8000000 01	0.3000000 02	0.2600000 02	0.1300000 02
10	0.7200000 02	0.6000000 01	0.2000000 02	0.1100000 02	0.8000000 01	0.3000000 02	0.2600000 02	0.1300000 02
11	0.7200000 02	0.6000000 01	0.2000000 02	0.1100000 02	0.8000000 01	0.3000000 02	0.2600000 02	0.1300000 02
12	0.7200000 02	0.6000000 01	M1= 0.57000 02		M2= 0.57000 02			
13	0.7200000 02	0.6000000 01	0.2000000 02	0.1100000 02	0.8000000 01	0.3000000 02	0.2600000 02	0.1300000 02
14	0.7200000 02	0.6000000 01	0.2000000 02	0.1100000 02	0.8000000 01	0.3000000 02	0.2600000 02	0.1300000 02
15	0.7200000 02	0.6000000 01	0.2000000 02	0.1100000 02	0.8000000 01	0.3000000 02	0.2600000 02	0.1300000 02
16	0.7200000 02	0.6000000 01	0.2000000 02	0.1100000 02	0.8000000 01	0.3000000 02	0.2600000 02	0.1300000 02
17	0.7200000 02	0.6000000 01	0.2000000 02	0.1100000 02	0.8000000 01	0.3000000 02	0.2600000 02	0.1300000 02
18	0.7200000 02	0.6000000 01	0.2000000 02	0.1100000 02	0.8000000 01	0.3000000 02	0.2600000 02	0.1300000 02
19	0.7200000 02	0.6000000 01	0.2000000 02	0.1100000 02	0.8000000 01	0.3000000 02	0.2600000 02	0.1300000 02
20	0.7200000 02	0.6000000 01	0.2000000 02	0.1100000 02	0.8000000 01	0.3000000 02	0.2600000 02	0.1300000 02
21	0.7200000 02	0.6000000 01	0.2000000 02	0.1100000 02	0.8000000 01	0.3000000 02	0.2600000 02	0.1300000 02
22	0.7200000 02	0.6000000 01	0.2000000 02	0.1100000 02	0.8000000 01	0.3000000 02	0.2600000 02	0.1300000 02
23	0.7200000 02	0.6000000 01	0.2000000 02	0.1100000 02	0.8000000 01*	0.3000000 02	0.2600000 02	0.1300000 02
24	0.7200000 02	0.6000000 01	M1= 0.57000 02		M2= 0.57000 02			

R E I N F.   S T E E L   C O N T E N T

	DECK		GIRDER TOP		GIRDER BOTTOM	
ELEM #	AREA	DIST.TO BASE	AREA	DIST.TO BASE	AREA	DIST.TO BASE
1	0.6750000 01	0.5700000 02	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
2	0.6750000 01	0.5700000 02	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
3	0.6750000 01	0.5700000 02	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
4	0.6750000 01	0.5700000 02	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
5	0.6750000 01	0.5700000 02	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
6	0.6750000 01	0.5700000 02	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
7	0.6750000 01	0.5700000 02	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
8	0.6750000 01	0.5700000 02	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
9	0.6750000 01	0.5700000 02	0.2000000 01	0.5100000 02	0.0000000 00	0.0000000 00
10	0.6750000 01	0.5700000 02	0.2000000 01	0.5100000 02	0.0000000 00	0.0000000 00
11	0.1125000 02	0.5700000 02	0.2000000 01	0.5100000 02	0.2000000 01	0.2000000 01
12	0.1125000 02	0.5700000 02	0.2000000 01	0.5100000 02	0.2000000 01	0.2000000 01
13	0.1125000 02	0.5700000 02	0.2000000 01	0.5100000 02	0.2000000 01	0.2000000 01
14	0.6750000 01	0.5700000 02	0.2000000 01	0.5100000 02	0.0000000 00	0.0000000 00
15	0.6750000 01	0.5700000 02	0.2000000 01	0.5100000 02	0.0000000 00	0.0000000 00
16	0.6750000 01	0.5700000 02	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
17	0.6750000 01	0.5700000 02	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
18	0.6750000 01	0.5700000 02	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
19	0.6750000 01	0.5700000 02	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
20	0.6750000 01	0.5700000 02	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
21	0.6750000 01	0.5700000 02	0.2000000 01	0.5100000 02	0.0000000 00	0.0000000 00
22	0.6750000 01	0.5700000 02	0.2000000 01	0.5100000 02	0.0000000 00	0.0000000 00
23	0.1125000 02	0.5700000 02	0.2000000 01	0.5100000 02	0.2000000 01	0.2000000 01
24	0.1125000 02	0.5700000 02	0.2000000 01	0.5100000 02	0.2000000 01	0.2000000 01

LOAD CASES

(1) GIRDER DEAD LOAD
(2) PRESTRESSING
(3) DECK DEAD LOAD
(4) SUPPORT DISPLACEMENT
(5) LIVE LOAD
(6) TEMPERATURE
(7) CREEP, SHRINKAGE AND RELAXATION

EFFECT TABLE

0 NONE
1 CREEP
2 SHRINKAGE
3 RELAXATION
4 ALL

LOAD CASE #	TYPE	COMP.SECTION	# STEPS	PRINT STEP	EFFECT	F. DAY	L. DAY	HINGED
1	1	0	1	0	0	0	0	0
2	2	0	1	0	0	0	0	0
3	3	0	1	0	0	0	0	0
4	5	1	[illegible]	0	0	0	0	0
LOCA (1	2	3	4	5	6	7	8)	

PRESCRIBED DISPLACEMENTS

SUP #	NODE #	DISP.VALUE
1	1	0.0000D 00
2	12	0.0000D 00
3	13	0.0000D 00
4	24	0.0000D 00
5	25	0.0000D 00

TEMPERATURE VARIATION (F)

TOP DECK	TOP GIRDER	BOTTOM GIRDER
0	0	0

LIVE LOAD

NODAL APPLIED LOADS (+)R,UP,CC

NODE #	FX	FY	MZ
1	0.000000000D 00	0.000000000D 00	0.000000000D 00
2	0.000000000D 00	0.000000000D 00	0.000000000D 00
3	0.000000000D 00	0.000000000D 00	0.000000000D 00
4	0.000000000D 00	0.000000000D 00	0.000000000D 00
5	0.000000000D 00	0.000000000D 00	0.000000000D 00
6	0.000000000D 00	0.000000000D 00	0.000000000D 00
7	0.000000000D 00	0.000000000D 00	0.000000000D 00
8	0.000000000D 00	0.000000000D 00	0.000000000D 00
9	0.000000000D 00	0.000000000D 00	0.000000000D 00
10	0.000000000D 00	0.000000000D 00	0.000000000D 00
11	0.000000000D 00	0.000000000D 00	0.000000000D 00
12	0.000000000D 00	0.000000000D 00	0.000000000D 00
13	0.000000000D 00	0.000000000D 00	0.000000000D 00
14	0.000000000D 00	0.000000000D 00	0.000000000D 00
15	0.000000000D 00	0.000000000D 00	0.000000000D 00
16	0.000000000D 00	0.000000000D 00	0.000000000D 00
17	0.000000000D 00	0.000000000D 00	0.000000000D 00
18	0.000000000D 00	0.000000000D 00	0.000000000D 00
19	0.000000000D 00	0.000000000D 00	0.000000000D 00
20	0.000000000D 00	0.000000000D 00	0.000000000D 00
21	0.000000000D 00	0.000000000D 00	0.000000000D 00
22	0.000000000D 00	0.000000000D 00	0.000000000D 00
23	0.000000000D 00	0.000000000D 00	0.000000000D 00
24	0.000000000D 00	0.000000000D 00	0.000000000D 00
25	0.000000000D 00	0.000000000D 00	0.000000000D 00

E L E M E N T   A P P L I E D   L O A D S   (+100=N

ELEM #	U.DIST.	CONC.	FR.L.NODE
1	0,100000000 04	0.000000000 00	0.000000000 00
2	0,100000000 04	0.000000000 00	0.000000000 00
3	0,100000000 04	0.000000000 00	0.000000000 00
4	0,100000000 04	0.000000000 00	0.000000000 00
5	0,100000000 04	0.000000000 00	0.000000000 00
6	0,100000000 04	0.000000000 00	0.000000000 00
7	0,100000000 04	0.000000000 00	0.000000000 00
8	0,100000000 04	0.000000000 00	0.000000000 00
9	0,100000000 04	0.000000000 00	0.000000000 00
10	0,100000000 04	0.000000000 00	0.000000000 00
11	0,100000000 04	0.000000000 00	0.000000000 00
12	0,000000000 00	0.000000000 00	0.000000000 00
13	0,000000000 00	0.000000000 00	0.000000000 00
14	0,000000000 00	0.000000000 00	0.000000000 00
15	0,000000000 00	0.000000000 00	0.000000000 00
16	0,000000000 00	0.000000000 00	0.000000000 00
17	0,000000000 00	0.000000000 00	0.000000000 00
18	0,000000000 00	0.000000000 00	0.000000000 00
19	0,000000000 00	0.000000000 00	0.000000000 00
20	0,000000000 00	0.000000000 00	0.000000000 00
21	0,000000000 00	0.000000000 00	0.000000000 00
22	0,000000000 00	0.000000000 00	0.000000000 00
23	0,000000000 00	0.000000000 00	0.000000000 00
24	0,000000000 00	0.000000000 00	0.000000000 00

DISPLACEMENT DRIVEN METHOD FOR L.L.

NODE # 6   AT   -0.500000000-01

L.L UPPER LIMIT = 0,5000 01 X

P R E S T R E S S I N G

PRESTRESSING AREA AND INITIAL FORCE

(PRE-TENSIONED CABLE)

(LOW-RELAXATION STEEL)

FROM ELEM #	TO ELEM #	AREA	INITIAL FORCE	JACKING SIDE
1	11	0.272000 01	0.5160000 06	1
13	23	0.272000 01	0.5160000 06	1

C A B L E   P R O F I L E

(STRAIGHT)

NODE #	DIST.TO BASE
1	0,300000 01
2	0,300000 01
3	0,300000 01
4	0,300000 01
5	0,300000 01
6	0,300000 01
7	0,300000 01
8	0,300000 01
9	0,300000 01
10	0,300000 01
11	0,300000 01
12	0,300000 01
13	0,300000 01
14	0,300000 01
15	0,300000 01
16	0,300000 01
17	0,300000 01
18	0,300000 01
19	0,300000 01
20	0,300000 01
21	0,300000 01
22	0,300000 01
23	0,300000 01
24	0,300000 01
25	0,000000 00

RESULTS

NBANDW = 6

GLOBAL DISPLACEMENT

NODE #	X	Y	THETA
1	1	0	2
2	3	4	5
3	6	7	8
4	9	10	11
5	12	13	14
6	15	16	17
7	18	19	20
8	21	22	23
9	24	25	26
10	27	28	29
11	30	31	32
12	33	0	34
13	35	0	36
14	37	38	39
15	40	41	42
16	43	44	45
17	46	47	48
18	49	50	51
19	52	53	54
20	55	56	57
21	58	59	60
22	61	62	63
23	64	65	66
24	67	0	68
25	0	0	0

STORAGE NEEDED = 17212

DEAD LOAD

ELEM #	GIRDER	DECK
1	0.692664000 02	0.374976000 02
2	0.692664000 02	0.374976000 02
3	0.692664000 02	0.374976000 02
4	0.692664000 02	0.374976000 02
5	0.692664000 02	0.374976000 02
6	0.692664000 02	0.374976000 02
7	0.692664000 02	0.374976000 02
8	0.692664000 02	0.374976000 02
9	0.692664000 02	0.374976000 02
10	0.692664000 02	0.374976000 02
11	0.692664000 02	0.374976000 02
12	0.000000000 00	0.374976000 02
13	0.692664000 02	0.374976000 02
14	0.692664000 02	0.374976000 02
15	0.692664000 02	0.374976000 02
16	0.692664000 02	0.374976000 02
17	0.692664000 02	0.374976000 02
18	0.692664000 02	0.374976000 02
19	0.692664000 02	0.374976000 02
20	0.692664000 02	0.374976000 02
21	0.692664000 02	0.374976000 02
22	0.692664000 02	0.374976000 02
23	0.692664000 02	0.374976000 02
24	0.000000000 00	0.374976000 02

O R I G I N A L   S E C T I O N   P R O P E R T I E S   (TRANSFORMED)

(NON-COMPOSITE SECTION)   (COMPOSITE SECTION)

ELEM #	CENTROID	AREA	AREA MOM.	INERTIA	CENTROID	AREA	AREA MOM.	INERTIA
1	0.2454510 02	0.7980000 03	0.1958700 05	0.2641490 06	0.3500510 02	0.1177500 04	0.4121850 05	0.5360600 06
2	0.2454510 02	0.7980000 03	0.1958700 05	0.2641490 06	0.3500510 02	0.1177500 04	0.4121850 05	0.5360600 06
3	0.2454510 02	0.7980000 03	0.1958700 05	0.2641490 06	0.3500510 02	0.1177500 04	0.4121850 05	0.5360600 06
4	0.2454510 02	0.7980000 03	0.1958700 05	0.2641490 06	0.3500510 02	0.1177500 04	0.4121850 05	0.5360600 06
5	0.2454510 02	0.7980000 03	0.1958700 05	0.2641490 06	0.3500510 02	0.1177500 04	0.4121850 05	0.5360600 06
6	0.2454510 02	0.7980000 03	0.1958700 05	0.2641490 06	0.3500510 02	0.1177500 04	0.4121850 05	0.5360600 06
7	0.2454510 02	0.7980000 03	0.1958700 05	0.2641490 06	0.3500510 02	0.1177500 04	0.4121850 05	0.5360600 06
8	0.2454510 02	0.7980000 03	0.1958700 05	0.2641490 06	0.3500510 02	0.1177500 04	0.4121850 05	0.5360600 06
9	0.2496560 02	0.8108890 03	0.2024430 05	0.2730260 06	0.3517830 02	0.1190390 04	0.4187580 05	0.5393220 06
10	0.2496560 02	0.8108890 03	0.2024430 05	0.2730260 06	0.3517830 02	0.1190390 04	0.4187580 05	0.5393220 06
11	0.2460630 02	0.8237780 03	0.2027010 05	0.2797170 06	0.3534480 02	0.1232280 04	0.4355460 05	0.5672850 06
12	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.4085000 03	0.0000000 00	0.0000000 00
13	0.2460630 02	0.8237780 03	0.2027010 05	0.2797170 06	0.3534480 02	0.1232280 04	0.4355460 05	0.5672850 06
14	0.2496560 02	0.8108890 03	0.2024430 05	0.2730260 06	0.3517830 02	0.1190390 04	0.4187580 05	0.5393220 06
15	0.2496560 02	0.8108890 03	0.2024430 05	0.2730260 06	0.3517830 02	0.1190390 04	0.4187580 05	0.5393220 06
16	0.2454510 02	0.7980000 03	0.1958700 05	0.2641490 06	0.3500510 02	0.1177500 04	0.4121850 05	0.5360600 06
17	0.2454510 02	0.7980000 03	0.1958700 05	0.2641490 06	0.3500510 02	0.1177500 04	0.4121850 05	0.5360600 06
18	0.2454510 02	0.7980000 03	0.1958700 05	0.2641490 06	0.3500510 02	0.1177500 04	0.4121850 05	0.5360600 06
19	0.2454510 02	0.7980000 03	0.1958700 05	0.2641490 06	0.3500510 02	0.1177500 04	0.4121850 05	0.5360600 06
20	0.2454510 02	0.7980000 03	0.1958700 05	0.2641490 06	0.3500510 02	0.1177500 04	0.4121850 05	0.5360600 06
21	0.2496560 02	0.8108890 03	0.2024430 05	0.2730260 06	0.3517830 02	0.1190390 04	0.4187580 05	0.5393220 06
22	0.2496560 02	0.8108890 03	0.2024430 05	0.2730260 06	0.3517830 02	0.1190390 04	0.4187580 05	0.5393220 06
23	0.2460630 02	0.8237780 03	0.2027010 05	0.2797170 06	0.3534480 02	0.1232280 04	0.4355460 05	0.5672850 06
24	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.4085000 03	0.0000000 00	0.0000000 00

L O A D   C A S E # 1   STEP # 1/ 1   ITER. IN THE STEP= 2   TOTAL # ITER.= 4

N E W   S E C T I O N   P R O P E R T I E S   (TRANSFORMED, TO BOTTOM)

(NON COMPOSITE SECTION)

ELEM #	CENTROID	AREA	AREA MOM.	INERTIA
1	0.2454510 02	0.7980000 03	0.1958700 05	0.7449140 06
2	0.2454510 02	0.7980000 03	0.1958700 05	0.7449140 06
3	0.2454510 02	0.7980000 03	0.1958700 05	0.7449140 06
4	0.2454510 02	0.7980000 03	0.1958700 05	0.7449140 06
5	0.2454510 02	0.7980000 03	0.1958700 05	0.7449140 06
6	0.2454510 02	0.7980000 03	0.1958700 05	0.7449140 06
7	0.2454510 02	0.7980000 03	0.1958700 05	0.7449140 06
8	0.2454510 02	0.7980000 03	0.1958700 05	0.7449140 06
9	0.2496560 02	0.8108890 03	0.2024430 05	0.7784380 06
10	0.2496560 02	0.8108890 03	0.2024430 05	0.7784380 06
11	0.2460630 02	0.8237780 03	0.2027010 05	0.7784900 06
12	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
13	0.2460630 02	0.8237780 03	0.2027010 05	0.7784900 06
14	0.2496560 02	0.8108890 03	0.2024430 05	0.7784380 06
15	0.2496560 02	0.8108890 03	0.2024430 05	0.7784380 06
16	0.2454510 02	0.7980000 03	0.1958700 05	0.7449140 06
17	0.2454510 02	0.7980000 03	0.1958700 05	0.7449140 06
18	0.2454510 02	0.7980000 03	0.1958700 05	0.7449140 06
19	0.2454510 02	0.7980000 03	0.1958700 05	0.7449140 06
20	0.2454510 02	0.7980000 03	0.1958700 05	0.7449140 06
21	0.2496560 02	0.8108890 03	0.2024430 05	0.7784380 06
22	0.2496560 02	0.8108890 03	0.2024430 05	0.7784380 06
23	0.2460630 02	0.8237780 03	0.2027010 05	0.7784900 06
24	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00

NODAL DISPLACEMENTS (+)R,UP,CC

NODE #	X (THIS STEP)	Y (THIS STEP)	THETA (THIS STEP)	X (TOTAL)	Y (TOTAL)	THETA (TOTAL)
1	-0,2864770-01	0,0000000 00	-0,1168900-02	-0,2864770-01	0,0000000 00	-0,1168900-02
2	-0,2732190-01	-0,8340600-01	-0,1114880-02	-0,2732190-01	-0,8340600-01	-0,1114880-02
3	-0,2361160-01	-0,1591860 00	-0,9637300-03	-0,2361160-01	-0,1591860 00	-0,9637300-03
4	-0,1805230-01	-0,2211300 00	-0,7372270-03	-0,1805230-01	-0,2211300 00	-0,7372270-03
5	-0,1117810-01	-0,2645980 00	-0,4571620-03	-0,1117810-01	-0,2645980 00	-0,4571620-03
6	-0,3523950-02	-0,2865140 00	-0,1453240-03	-0,3523950-02	-0,2865140 00	-0,1453240-03
7	0,4375270-02	-0,2853860 00	0,1765010-03	0,4375270-02	-0,2853860 00	0,1765010-03
8	0,1198460-01	-0,2612670 00	0,4865240-03	0,1198460-01	-0,2612670 00	0,4865240-03
9	0,1876990-01	-0,2157950 00	0,7629570-03	0,1876990-01	-0,2157950 00	0,7629570-03
10	0,2410900-01	-0,1524450 00	0,9768130-03	0,2410900-01	-0,1524450 00	0,9768130-03
11	0,2758430-01	-0,7614890-01	0,1116020-02	0,2758430-01	-0,7614890-01	0,1116020-02
12	0,2864770-01	0,0000000 00	0,1159240-02	0,2864770-01	0,0000000 00	0,1159240-02
13	-0,2789420-01	0,0000000 00	-0,1130350-02	-0,2789420-01	0,0000000 00	-0,1130350-02
14	-0,2683970-01	-0,7424540-01	-0,1087490-02	-0,2683970-01	-0,7424540-01	-0,1087490-02
15	-0,2339540-01	-0,1485230 00	-0,9495320-03	-0,2339540-01	-0,1485230 00	-0,9495320-03
16	-0,1810930-01	-0,2099750 00	-0,7377980-03	-0,1810930-01	-0,2099750 00	-0,7377980-03
17	-0,1140040-01	-0,2537370 00	-0,4644670-03	-0,1140040-01	-0,2537370 00	-0,4644670-03
18	-0,3889260-02	-0,2764020 00	-0,1584540-03	-0,3889260-02	-0,2764020 00	-0,1584540-03
19	0,3889260-02	-0,2764020 00	0,1584540-03	0,3889260-02	-0,2764020 00	0,1584540-03
20	0,1140040-01	-0,2537370 00	0,4644670-03	0,1140040-01	-0,2537370 00	0,4644670-03
21	0,1810930-01	-0,2099750 00	0,7377980-03	0,1810930-01	-0,2099750 00	0,7377980-03
22	0,2339540-01	-0,1485230 00	0,9495320-03	0,2339540-01	-0,1485230 00	0,9495320-03
23	0,2683970-01	-0,7424540-01	0,1087490-02	0,2683970-01	-0,7424540-01	0,1087490-02
24	0,2789420-01	0,0000000 00	0,1130350-02	0,2789420-01	0,0000000 00	0,1130350-02
25	0,0000000 00	0,0000000 00	0,0000000 00	0,0000000 00	0,0000000 00	0,0000000 00

ELEMENT RESULTANT FORCES (+) TENSION,COMP.UP,LEFT UP
(TOTAL)

ELEM #	AXIAL	MOMENT	SHEAR
1	-0,4701920-01	0,8902100 06	0,2472810 05
2	-0,4701920-01	0,2491100 07	0,1974090 05
3	-0,4701920-01	0,3732900 07	0,1475370 05
4	-0,4701920-01	0,4618630 07	0,9766560 04
5	-0,4701920-01	0,5139290 07	0,4779360 04
6	-0,4701920-01	0,5303870 07	-0,2077990 03
7	-0,4701920-01	0,5109370 07	-0,5194960 04
8	-0,4701920-01	0,4555790 07	-0,1018220 05
9	-0,4701920-01	0,3643130 07	-0,1516930 05
10	-0,4701920-01	0,2371400 07	-0,2015650 05
11	-0,4701920-01	0,8228830 06	-0,2493590 05
12	0,0000000 00	0,0000000 00	0,0000000 00
13	-0,4475270-01	0,8160260 06	0,2472810 05
14	-0,4475270-01	0,2350210 07	0,1994870 05
15	-0,4475270-01	0,3606980 07	0,1496150 05
16	-0,4475270-01	0,4504670 07	0,9974360 04
17	-0,4475270-01	0,5043290 07	0,4987180 04
18	-0,4475270-01	0,5222820 07	0,3827150-12
19	-0,4475270-01	0,5043290 07	-0,4987180 04
20	-0,4475270-01	0,4504670 07	-0,9974360 04
21	-0,4475270-01	0,3606980 07	-0,1496150 05
22	-0,4475270-01	0,2350210 07	-0,1994870 05
23	-0,4475270-01	0,8160260 06	-0,2472810 05
24	0,0000000 00	0,0000000 00	0,0000000 00

NODAL EXTERNAL REACTIONS (+)R,UP,CC
(TOTAL)

NODE #	RX	RY	MZ
1	0,4701920-01	0,2472810 05	0,2940320 00
12	-0,4701920-01	0,2493590 05	-0,2780510 00
13	0,4475270-01	0,2472810 05	0,2654770 00
24	-0,4475270-01	0,2472810 05	-0,2654770 00
25	0,0000000 00	0,0000000 00	0,0000000 00

F I N A L   C A B L E   P R O P E R T I E S   (UP TO THIS STEP)

ELEM #	FORCE	STRESS	STRAIN	E MOD
1	0.000000 00	0.000000 00	0.000000 00	0.000000 00
2	0.000000 00	0.000000 00	0.000000 00	0.000000 00
3	0.000000 00	0.000000 00	0.000000 00	0.000000 00
4	0.000000 00	0.000000 00	0.000000 00	0.000000 00
5	0.000000 00	0.000000 00	0.000000 00	0.000000 00
6	0.000000 00	0.000000 00	0.000000 00	0.000000 00
7	0.000000 00	0.000000 00	0.000000 00	0.000000 00
8	0.000000 00	0.000000 00	0.000000 00	0.000000 00
9	0.000000 00	0.000000 00	0.000000 00	0.000000 00
10	0.000000 00	0.000000 00	0.000000 00	0.000000 00
11	0.000000 00	0.000000 00	0.000000 00	0.000000 00
12	0.000000 00	0.000000 00	0.000000 00	0.000000 00
13	0.000000 00	0.000000 00	0.000000 00	0.000000 00
14	0.000000 00	0.000000 00	0.000000 00	0.000000 00
15	0.000000 00	0.000000 00	0.000000 00	0.000000 00
16	0.000000 00	0.000000 00	0.000000 00	0.000000 00
17	0.000000 00	0.000000 00	0.000000 00	0.000000 00
18	0.000000 00	0.000000 00	0.000000 00	0.000000 00
19	0.000000 00	0.000000 00	0.000000 00	0.000000 00
20	0.000000 00	0.000000 00	0.000000 00	0.000000 00
21	0.000000 00	0.000000 00	0.000000 00	0.000000 00
22	0.000000 00	0.000000 00	0.000000 00	0.000000 00
23	0.000000 00	0.000000 00	0.000000 00	0.000000 00
24	0.000000 00	0.000000 00	0.000000 00	0.000000 00

S T R A I N S   A T   T H E   G I R D E R S

	(UP TO THIS STEP)				(MAX. REACHED)			
ELEM #	BOTTOM GIRDER	TOP GIRDER	BOTTOM DECK	TOP DECK	BOTTOM GIRDER	TOP GIRDER	BOTTOM DECK	TOP DECK
1	0.1841410-04	-0.2209760-04	0.0000000 00	0.0000000 00	0.1841410-04	-0.2209760-04	0.0000000 00	0.0000000 00
2	0.5152670-04	-0.6183610-04	0.0000000 00	0.0000000 00	0.5152670-04	-0.6183610-04	0.0000000 00	0.0000000 00
3	0.7721580-04	-0.9266130-04	0.0000000 00	0.0000000 00	0.7721580-04	-0.9266130-04	0.0000000 00	0.0000000 00
4	0.9547520-04	-0.1145730-03	0.0000000 00	0.0000000 00	0.9547520-04	-0.1145730-03	0.0000000 00	0.0000000 00
5	0.1063070-03	-0.1275720-03	0.0000000 00	0.0000000 00	0.1063070-03	-0.1275720-03	0.0000000 00	0.0000000 00
6	0.1097110-03	-0.1316570-03	0.0000000 00	0.0000000 00	0.1097110-03	-0.1316570-03	0.0000000 00	0.0000000 00
7	0.1056880-03	-0.1268290-03	0.0000000 00	0.0000000 00	0.1056880-03	-0.1268290-03	0.0000000 00	0.0000000 00
8	0.9423730-04	-0.1130880-03	0.0000000 00	0.0000000 00	0.9423730-04	-0.1130880-03	0.0000000 00	0.0000000 00
9	0.7415350-04	-0.8623860-04	0.0000000 00	0.0000000 00	0.7415350-04	-0.8623880-04	0.0000000 00	0.0000000 00
10	0.4826830-04	-0.5613490-04	0.0000000 00	0.0000000 00	0.4826830-04	-0.5613490-04	0.0000000 00	0.0000000 00
11	0.1611260-04	-0.1924750-04	0.0000000 00	0.0000000 00	0.1611260-04	-0.1924750-04	0.0000000 00	0.0000000 00
12	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
13	0.1597830-04	-0.1908710-04	0.0000000 00	0.0000000 00	0.1597830-04	-0.1908710-04	0.0000000 00	0.0000000 00
14	0.4783690-04	-0.5563310-04	0.0000000 00	0.0000000 00	0.4783690-04	-0.5563310-04	0.0000000 00	0.0000000 00
15	0.7341760-04	-0.8538290-04	0.0000000 00	0.0000000 00	0.7341760-04	-0.8538290-04	0.0000000 00	0.0000000 00
16	0.9317990-04	-0.1118190-03	0.0000000 00	0.0000000 00	0.9317990-04	-0.1118190-03	0.0000000 00	0.0000000 00
17	0.1043210-03	-0.1251890-03	0.0000000 00	0.0000000 00	0.1043210-03	-0.1251890-03	0.0000000 00	0.0000000 00
18	0.1080350-03	-0.1296450-03	0.0000000 00	0.0000000 00	0.1080350-03	-0.1296450-03	0.0000000 00	0.0000000 00
19	0.1043210-03	-0.1251890-03	0.0000000 00	0.0000000 00	0.1043210-03	-0.1251890-03	0.0000000 00	0.0000000 00
20	0.9317990-04	-0.1118190-03	0.0000000 00	0.0000000 00	0.9317990-04	-0.1118190-03	0.0000000 00	0.0000000 00
21	0.7341760-04	-0.8538290-04	0.0000000 00	0.0000000 00	0.7341760-04	-0.8538290-04	0.0000000 00	0.0000000 00
22	0.4783690-04	-0.5563310-04	0.0000000 00	0.0000000 00	0.4783690-04	-0.5563310-04	0.0000000 00	0.0000000 00
23	0.1597830-04	-0.1908710-04	0.0000000 00	0.0000000 00	0.1597830-04	-0.1908710-04	0.0000000 00	0.0000000 00
24	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00

C R A C K I N G   L E N G T H   &   W I D T H

GIRDER RUPTURE STRAIN = 0.13000D-03
DECK RUPTURE STRAIN = 0.13000D-03

ELEM #	BOTTOM GIRDER	TOP GIRDER	BOTTOM DECK	TOP DECK	BOTTOM GIRDER	TOP GIRDER	BOTTOM DECK	TOP DECK
1	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
2	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
3	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
4	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
5	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
6	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
7	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
8	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
9	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
10	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
11	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
12	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
13	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
14	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
15	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
16	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
17	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
18	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
19	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
20	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
21	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
22	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
23	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
24	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00

C R A C K I N G   P A T T E R N

GIRDER RUPTURE STRAIN = 0.13000D-03
DECK RUPTURE STRAIN = 0.13000D-03

ELEM #	LAYERS																			
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
10	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
11	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
13	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
14	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
15	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
16	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
17	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
18	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
19	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
20	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
21	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
22	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
23	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
24	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

C R A C K   A N G L E S   (DEGREES)

1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

REINF. STEEL STRESSES

ELEM #	DECK STEEL	TOP STEEL	BOTTOM STEEL
1	0.000000 00	0.000000 00	0.000000 00
2	0.000000 00	0.000000 00	0.000000 00
3	0.000000 00	0.000000 00	0.000000 00
4	0.000000 00	0.000000 00	0.000000 00
5	0.000000 00	0.000000 00	0.000000 00
6	0.000000 00	0.000000 00	0.000000 00
7	0.000000 00	0.000000 00	0.000000 00
8	0.000000 00	0.000000 00	0.000000 00
9	0.000000 00	-0.224250 04	0.000000 00
10	0.000000 00	-0.145970 04	0.000000 00
11	0.000000 00	-0.501210 03	0.429290 03
12	0.000000 00	0.000000 00	0.000000 00
13	0.000000 00	-0.497030 03	0.425710 03
14	0.000000 00	-0.144670 04	0.000000 00
15	0.000000 00	-0.222030 04	0.000000 00
16	0.000000 00	0.000000 00	0.000000 00
17	0.000000 00	0.000000 00	0.000000 00
18	0.000000 00	0.000000 00	0.000000 00
19	0.000000 00	0.000000 00	0.000000 00
20	0.000000 00	0.000000 00	0.000000 00
21	0.000000 00	-0.222030 04	0.000000 00
22	0.000000 00	-0.144670 04	0.000000 00
23	0.000000 00	-0.497030 03	0.425710 03
24	0.000000 00	0.000000 00	0.000000 00

Y I E L D I N G (NGL=3)

ELEM # REINF.STEEL (OUTER) 6 L A Y E R S

1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
10	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
11	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
13	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
14	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
15	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
16	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
17	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
18	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
19	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
20	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
21	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
22	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
23	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
24	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

C H E C K I N G E L E M E N T S

ELEMENT # 6

#	POSITION	LAYER AREA	STRAIN	STRESS	INST.MODULUS
30	0.000000 00	0.000000 00	0.000000000 00	0.000000000 00	0.350000000 07
29	0.000000 00	0.000000 00	0.000000000 00	0.000000000 00	0.350000000 07
28	0.000000 00	0.000000 00	0.000000000 00	0.000000000 00	0.350000000 07
27	0.000000 00	0.000000 00	0.000000000 00	0.000000000 00	0.350000000 07
26	0.000000 00	0.000000 00	0.000000000 00	0.000000000 00	0.350000000 07
25	0.000000 00	0.000000 00	0.000000000 00	0.000000000 00	0.350000000 07
24	0.000000 00	0.000000 00	0.000000000 00	0.000000000 00	0.350000000 07
23	0.000000 00	0.000000 00	0.000000000 00	0.000000000 00	0.350000000 07
22	0.000000 00	0.000000 00	0.000000000 00	0.000000000 00	0.350000000 07
21	0.000000 00	0.000000 00	0.000000000 00	0.000000000 00	0.350000000 07
20	0.529000 02	0.440000 02	-0.126740300-03	-0.570331330 03	0.450000000 07
19	0.507000 02	0.440000 02	-0.116906770-03	-0.526080450 03	0.450000000 07
18	0.485000 02	0.440000 02	-0.107073240-03	-0.481829570 03	0.450000000 07
17	0.463000 02	0.440000 02	-0.972397070-04	-0.437578680 03	0.450000000 07
16	0.441000 02	0.440000 02	-0.874061780-04	-0.393327800 03	0.450000000 07
15	0.415000 02	0.240000 02	-0.757847340-04	-0.341031300 03	0.450000000 07
14	0.385000 02	0.240000 02	-0.623753750-04	-0.280689190 03	0.450000000 07
13	0.355000 02	0.240000 02	-0.489660170-04	-0.220347070 03	0.450000000 07
12	0.325000 02	0.240000 02	-0.355566580-04	-0.160004960 03	0.450000000 07
11	0.295000 02	0.240000 02	-0.221472990-04	-0.996628440 02	0.450000000 07
10	0.265000 02	0.240000 02	-0.873794100-05	-0.393207340 02	0.450000000 07
9	0.235000 02	0.240000 02	0.467141760-05	0.210213790 02	0.450000000 07
8	0.205000 02	0.240000 02	0.180807760-04	0.813634920 02	0.450000000 07
7	0.175000 02	0.240000 02	0.314901350-04	0.141705610 03	0.450000000 07
6	0.145000 02	0.240000 02	0.448994930-04	0.202047720 03	0.450000000 07
5	0.117000 02	0.676000 02	0.574148940-04	0.258367020 03	0.450000000 07
4	0.910000 01	0.676000 02	0.690363380-04	0.310663520 03	0.450000000 07
3	0.650000 01	0.676000 02	0.806577830-04	0.362960040 03	0.450000000 07
2	0.390000 01	0.676000 02	0.922792270-04	0.415256520 03	0.450000000 07
1	0.130000 01	0.676000 02	0.103900670-03	0.467553020 03	0.450000000 07

ELEMENT # 10

#	POSITION	LAYER AREA	STRAIN	STRESS	INST.MODULUS
30	0.000000 00	0.000000 00	0.000000000 00	0.000000000 00	0.350000000 07
29	0.000000 00	0.000000 00	0.000000000 00	0.000000000 00	0.350000000 07
28	0.000000 00	0.000000 00	0.000000000 00	0.000000000 00	0.350000000 07
27	0.000000 00	0.000000 00	0.000000000 00	0.000000000 00	0.350000000 07
26	0.000000 00	0.000000 00	0.000000000 00	0.000000000 00	0.350000000 07
25	0.000000 00	0.000000 00	0.000000000 00	0.000000000 00	0.350000000 07
24	0.000000 00	0.000000 00	0.000000000 00	0.000000000 00	0.350000000 07
23	0.000000 00	0.000000 00	0.000000000 00	0.000000000 00	0.350000000 07
22	0.000000 00	0.000000 00	0.000000000 00	0.000000000 00	0.350000000 07
21	0.000000 00	0.000000 00	0.000000000 00	0.000000000 00	0.350000000 07
20	0.529000 02	0.440000 02	-0.124803740-03	-0.561616820 03	0.450000000 07
19	0.507000 02	0.440000 02	-0.115120460-03	-0.518042080 03	0.450000000 07
18	0.485000 02	0.440000 02	-0.105437190-03	-0.474467340 03	0.450000000 07
17	0.463000 02	0.440000 02	-0.957539100-04	-0.430892600 03	0.450000000 07
16	0.441000 02	0.440000 02	-0.860706350-04	-0.387317860 03	0.450000000 07
15	0.415000 02	0.240000 02	-0.746267630-04	-0.335820430 03	0.450000000 07
14	0.385000 02	0.240000 02	-0.614222960-04	-0.276400330 03	0.450000000 07
13	0.355000 02	0.240000 02	-0.482178290-04	-0.216980230 03	0.450000000 07
12	0.325000 02	0.240000 02	-0.350133610-04	-0.157560130 03	0.450000000 07
11	0.295000 02	0.240000 02	-0.218088940-04	-0.981400240 02	0.450000000 07
10	0.265000 02	0.240000 02	-0.860442720-05	-0.387199220 02	0.450000000 07
9	0.235000 02	0.240000 02	0.460004000-05	0.207001800 02	0.450000000 07
8	0.205000 02	0.240000 02	0.178045070-04	0.801202820 02	0.450000000 07
7	0.178000 02	0.240000 02	0.310089740-04	0.139540380 03	0.450000000 07
6	0.145000 02	0.240000 02	0.442134410-04	0.198960490 03	0.450000000 07
5	0.117000 02	0.676000 02	0.565376110-04	0.254419250 03	0.450000000 07
4	0.910000 01	0.676000 02	0.679814820-04	0.305916670 03	0.450000000 07
3	0.650000 01	0.676000 02	0.794253540-04	0.357414090 03	0.450000000 07
2	0.390000 01	0.676000 02	0.908692250-04	0.408911510 03	0.450000000 07
1	0.130000 01	0.676000 02	0.102313100-03	0.460408940 03	0.450000000 07

L O A D   C A S E # 2   STEP # 1/ 1   ITER. IN THE STEP= 3   TOTAL # ITER.= 5

N E W   S E C T I O N   P R O P E R T I E S   (TRANSFORMED, TO BOTTOM)

(NON COMPOSITE SECTION)

ELEM #	CENTROID	AREA	AREA MOM.	INERTIA
1	0.2454510 02	0.7980000 03	0.1958700 05	0.7449140 06
2	0.2454510 02	0.7980000 03	0.1958700 05	0.7449140 06
3	0.2454510 02	0.7980000 03	0.1958700 05	0.7449140 06
4	0.2454510 02	0.7980000 03	0.1958700 05	0.7449140 06
5	0.2454510 02	0.7980000 03	0.1958700 05	0.7449140 06
6	0.2454510 02	0.7980000 03	0.1958700 05	0.7449140 06
7	0.2454510 02	0.7980000 03	0.1958700 05	0.7449140 06
8	0.2454510 02	0.7980000 03	0.1958700 05	0.7449140 06
9	0.2496560 02	0.8108890 03	0.2024430 05	0.7784380 06
10	0.2496560 02	0.8108890 03	0.2024430 05	0.7784380 06
11	0.2460630 02	0.8237780 03	0.2027010 05	0.7784900 06
12	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
13	0.2460630 02	0.8237780 03	0.2027010 05	0.7784900 06
14	0.2496560 02	0.8108890 03	0.2024430 05	0.7784380 06
15	0.2496560 02	0.8108890 03	0.2024430 05	0.7784380 06
16	0.2454510 02	0.7980000 03	0.1958700 05	0.7449140 06
17	0.2454510 02	0.7980000 03	0.1958700 05	0.7449140 06
18	0.2454510 02	0.7980000 03	0.1958700 05	0.7449140 06
19	0.2454510 02	0.7980000 03	0.1958700 05	0.7449140 06
20	0.2454510 02	0.7980000 03	0.1958700 05	0.7449140 06
21	0.2496560 02	0.8108890 03	0.2024430 05	0.7784380 06
22	0.2496560 02	0.8108890 03	0.2024430 05	0.7784380 06
23	0.2460630 02	0.8237780 03	0.2027010 05	0.7784900 06
24	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00

N O D A L   D I S P L A C E M E N T S (+)R,UP,CC

(THIS STEP) (TOTAL)

NODE #	X	Y	THETA	X	Y	THETA
1	0.139135D 00	0.000000D 00	0.349902D-02	0.110487D 00	0.000000D 00	0.233013D-02
2	0.113537D 00	0.228824D 00	0.285719D-02	0.862151D-01	0.145618D 00	0.174231D-02
3	0.879393D-01	0.411436D 00	0.221536D-02	0.643275D-01	0.252250D 00	0.125163D-02
4	0.623417D-01	0.547836D 00	0.157353D-02	0.442894D-01	0.326705D 00	0.836300D-03
5	0.367440D-01	0.638024D 00	0.931695D-03	0.255660D-01	0.373425D 00	0.474534D-03
6	0.111464D-01	0.682000D 00	0.289862D-03	0.762241D-02	0.395482D 00	0.144534D-03
7	-0.144513D-01	0.679784D 00	-0.351970D-03	-0.100760D-01	0.394378D 00	-0.175470D-03
8	-0.400490D-01	0.631316D 00	-0.993803D-03	-0.280641D-01	0.370049D 00	-0.507279D-03
9	-0.656466D-01	0.536656D 00	-0.163564D-02	-0.466767D-01	0.320881D 00	-0.872678D-03
10	-0.911425D-01	0.396097D 00	-0.226879D-02	-0.670336D-01	0.243652D 00	-0.129197D-02
11	-0.116638D 00	0.209951D 00	-0.290194D-02	-0.890542D-01	0.133802D 00	-0.178592D-02
12	-0.139135D 00	0.000000D 00	-0.346021D-02	-0.110487D 00	0.000000D 00	-0.230098D-02
13	0.137482D 00	0.000000D 00	0.342916D-02	0.109588D 00	0.000000D 00	0.229881D-02
14	0.114986D 00	0.207901D 00	0.287088D-02	0.881463D-01	0.133656D 00	0.178339D-02
15	0.894901D-01	0.391811D 00	0.223773D-02	0.660947D-01	0.243288D 00	0.128820D-02
16	0.639942D-01	0.530135D 00	0.160456D-02	0.458848D-01	0.320159D 00	0.866783D-03
17	0.383965D-01	0.622559D 00	0.962749D-03	0.269961D-01	0.368822D 00	0.499282D-03
18	0.127988D-01	0.668771D 00	0.320916D-03	0.890957D-02	0.392368D 00	0.162463D-03
19	-0.127988D-01	0.668771D 00	-0.320916D-03	-0.890957D-02	0.392368D 00	-0.162463D-03
20	-0.383965D-01	0.622559D 00	-0.962749D-03	-0.269961D-01	0.368822D 00	-0.499282D-03
21	-0.639942D-01	0.530135D 00	-0.160456D-02	-0.458848D-01	0.320159D 00	-0.866783D-03
22	-0.894901D-01	0.391811D 00	-0.223773D-02	-0.660947D-01	0.243288D 00	-0.128820D-02
23	-0.114986D 00	0.207901D 00	-0.287088D-02	-0.881463D-01	0.133656D 00	-0.178339D-02
24	-0.137482D 00	0.000000D 00	-0.342916D-02	-0.109588D 00	0.000000D 00	-0.229881D-02
25	0.000000D 00	0.000000D 00	0.000000D 00	0.000000D 00	0.000000D 00	0.000000D 00

E L E M E N T   R E S U L T A N T   F O R C E S   (+) TENSION,COMP,UP,LEFT UP

(TOTAL)

ELEM #	AXIAL	MOMENT	SHEAR
1	-0.490960D 06	-0.968758D 07	0.247281D 05
2	-0.490960D 06	-0.808669D 07	0.197409D 05
3	-0.490960D 06	-0.684489D 07	0.147537D 05
4	-0.490960D 06	-0.598216D 07	0.970656D 04
5	-0.490960D 06	-0.543850D 07	0.477936D 04
6	-0.490960D 06	-0.527392D 07	-0.207799D 03
7	-0.490960D 06	-0.546842D 07	-0.519496D 04
8	-0.490960D 06	-0.602200D 07	-0.101822D 05
9	-0.491040D 06	-0.714286D 07	-0.151693D 05
10	-0.491040D 06	-0.861459D 07	-0.201565D 05
11	-0.491973D 06	-0.980683D 07	-0.249359D 05
12	0.000000D 00	0.000000D 00	0.000000D 00
13	-0.491973D 06	-0.981369D 07	0.247281D 05
14	-0.491040D 06	-0.843579D 07	0.199487D 05
15	-0.491040D 06	-0.717902D 07	0.149615D 05
16	-0.490960D 06	-0.607312D 07	0.997436D 04
17	-0.490960D 06	-0.553450D 07	0.498718D 04
18	-0.490960D 06	-0.535497D 07	-0.256914D-11
19	-0.490960D 06	-0.553450D 07	-0.498718D 04
20	-0.490960D 06	-0.607312D 07	-0.997436D 04
21	-0.491040D 06	-0.717902D 07	-0.149615D 05
22	-0.491040D 06	-0.843579D 07	-0.199487D 05
23	-0.491973D 06	-0.981369D 07	-0.247281D 05
24	0.000000D 00	0.000000D 00	0.000000D 00

N O D A L   E X T E R N A L   R E A C T I O N S   (+)R,UP,CC

(TOTAL)

NODE #	RX	RY	MZ
1	-0.149213D-02	0.247281D 05	-0.981690D-02
12	0.149213D-02	0.249359D 05	0.917854D-02
13	-0.142322D-02	0.247281D 05	-0.888618D-02
24	0.142322D-02	0.247281D 05	0.888618D-02
25	0.000000D 00	0.000000D 00	0.000000D 00

F I N A L   C A B L E   P R O P E R T I E S   (UP TO THIS STEP)

ELEM #	FORCE	STRESS	STRAIN	E MOD
1	0.490960 06	0.180500 06	0.644640-02	0.280000 08
2	0.490960 06	0.180500 06	0.644640-02	0.280000 08
3	0.490960 06	0.180500 06	0.644640-02	0.280000 08
4	0.490960 06	0.180500 06	0.644640-02	0.280000 08
5	0.490960 06	0.180500 06	0.644640-02	0.280000 08
6	0.490960 06	0.180500 06	0.644640-02	0.280000 08
7	0.490960 06	0.180500 06	0.644640-02	0.280000 08
8	0.490960 06	0.180500 06	0.644640-02	0.280000 08
9	0.491040 06	0.180530 06	0.644750-02	0.280000 08
10	0.491040 06	0.180530 06	0.644750-02	0.280000 08
11	0.491970 06	0.180870 06	0.645970-02	0.280000 08
12	0.000000 00	0.000000 00	0.000000 00	0.000000 00
13	0.491970 06	0.180870 06	0.645970-02	0.280000 08
14	0.491040 06	0.180530 06	0.644750-02	0.280000 08
15	0.491040 06	0.180530 06	0.644750-02	0.280000 08
16	0.490960 06	0.180500 06	0.644640-02	0.280000 08
17	0.490960 06	0.180500 06	0.644640-02	0.280000 08
18	0.490960 06	0.180500 06	0.644640-02	0.280000 08
19	0.490960 06	0.180500 06	0.644640-02	0.280000 08
20	0.490960 06	0.180500 06	0.644640-02	0.280000 08
21	0.491040 06	0.180530 06	0.644750-02	0.280000 08
22	0.491040 06	0.180530 06	0.644750-02	0.280000 08
23	0.491970 06	0.180870 06	0.645970-02	0.280000 08
24	0.000000 00	0.000000 00	0.000000 00	0.000000 00

CABLE ELONGATION BY PRESTRESSING (FRICTION INCLUDED)

CURVATURE FRICTION COEFFICIENT = 0.000000 00
WOBBLE FRICTION CEFFICIENT = 0.000000 00

FROM ELEM #	TO ELEM #	LENGHT	ELONGATION
1	11	0.780000 03	0.532530 01
13	23	0.780000 03	0.526470 01

S T R A I N S   A T   T H E   B O R D E R S

(UP TO THIS STEP)   (MAX. REACHED)

ELEM #	BOTTOM GIRDER	TOP GIRDER	BOTTOM DECK	TOP DECK	BOTTOM GIRDER	TOP GIRDER	BOTTOM DECK	TOP DECK
1	-0.3371090-03	0.1037540-03	0.0000000 00	0.0000000 00	-0.3371090-03	0.1037540-03	0.0000000 00	0.0000000 00
2	-0.3039940-03	0.6401520-04	0.0000000 00	0.0000000 00	-0.3039940-03	0.6401520-04	0.0000000 00	0.0000000 00
3	-0.2783070-03	0.3319000-04	0.0000000 00	0.0000000 00	-0.2783070-03	-0.9266130-04	0.0000000 00	0.0000000 00
4	-0.2600480-03	0.1127810-04	0.0000000 00	0.0000000 00	-0.2600480-03	-0.1145730-03	0.0000000 00	0.0000000 00
5	-0.2492160-03	-0.1720520-05	0.0000000 00	0.0000000 00	-0.2492160-03	-0.1275720-03	0.0000000 00	0.0000000 00
6	-0.2458120-03	-0.5805740-05	0.0000000 00	0.0000000 00	-0.2458120-03	-0.1316570-03	0.0000000 00	0.0000000 00
7	-0.2498350-03	-0.9777390-06	0.0000000 00	0.0000000 00	-0.2498350-03	-0.1268290-03	0.0000000 00	0.0000000 00
8	-0.2612860-03	0.1276360-04	0.0000000 00	0.0000000 00	-0.2612860-03	-0.1130680-03	0.0000000 00	0.0000000 00
9	-0.2799570-03	0.3451440-04	0.0000000 00	0.0000000 00	-0.2799570-03	-0.8623880-04	0.0000000 00	0.0000000 00
10	-0.3058420-03	0.6461830-04	0.0000000 00	0.0000000 00	-0.3058420-03	0.6461830-04	0.0000000 00	0.0000000 00
11	-0.3247390-03	0.9667010-04	0.0000000 00	0.0000000 00	-0.3247390-03	0.9667010-04	0.0000000 00	0.0000000 00
12	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
13	-0.3248730-03	0.9683050-04	0.0000000 00	0.0000000 00	-0.3248730-03	0.9683050-04	0.0000000 00	0.0000000 00
14	-0.3062730-03	0.6512000-04	0.0000000 00	0.0000000 00	-0.3062730-03	0.6512000-04	0.0000000 00	0.0000000 00
15	-0.2806920-03	0.3537030-04	0.0000000 00	0.0000000 00	-0.2806920-03	-0.8538290-04	0.0000000 00	0.0000000 00
16	-0.2623430-03	0.1403250-04	0.0000000 00	0.0000000 00	-0.2623430-03	-0.1118190-03	0.0000000 00	0.0000000 00
17	-0.2512020-03	0.6625580-06	0.0000000 00	0.0000000 00	-0.2512020-03	-0.1251890-03	0.0000000 00	0.0000000 00
18	-0.2474880-03	-0.3794100-05	0.0000000 00	0.0000000 00	-0.2474880-03	-0.1296450-03	0.0000000 00	0.0000000 00
19	-0.2512020-03	0.6625580-06	0.0000000 00	0.0000000 00	-0.2512020-03	-0.1251890-03	0.0000000 00	0.0000000 00
20	-0.2623430-03	0.1403250-04	0.0000000 00	0.0000000 00	-0.2623430-03	-0.1118190-03	0.0000000 00	0.0000000 00
21	-0.2806920-03	0.3537030-04	0.0000000 00	0.0000000 00	-0.2806920-03	-0.8538290-04	0.0000000 00	0.0000000 00
22	-0.3062730-03	0.6512000-04	0.0000000 00	0.0000000 00	-0.3062730-03	0.6512000-04	0.0000000 00	0.0000000 00
23	-0.3248730-03	0.9683050-04	0.0000000 00	0.0000000 00	-0.3248730-03	0.9683050-04	0.0000000 00	0.0000000 00
24	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00

C R A C K I N G   L E N G T H   &   W I D T H

GIRDER RUPTURE STRAIN = 0.13000D-03
DECK RUPTURE STRAIN = 0.13000D-03

ELEM #	BOTTOM GIRDER	TOP GIRDER	BOTTOM DECK	TOP DECK	BOTTOM GIRDER	TOP GIRDER	BOTTOM DECK	TOP DECK
1	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
2	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
3	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
4	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
5	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
6	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
7	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
8	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
9	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
10	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
11	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
12	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
13	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
14	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
15	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
16	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
17	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
18	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
19	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
20	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
21	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
22	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
23	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
24	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00

C R A C K I N G   P A T T E R N

GIRDER RUPTURE STRAIN = 0.13000D-03
DECK RUPTURE STRAIN = 0.13000D-03

ELEM # — L A Y E R S

ELEM #																				
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
10	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
11	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
13	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
14	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
15	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
16	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
17	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
18	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
19	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
20	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
21	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
22	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
23	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
24	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

C R A C K   A N G L E S (DEGREES)

1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

REINF. STEEL STRESSES

ELEM #	DECK STEEL	TOP STEEL	BOTTOM STEEL
1	0,000000 00	0.000000 00	0,000000 00
2	0,000000 00	0.000000 00	0,000000 00
3	0,000000 00	0.000000 00	0,000000 00
4	0,000000 00	0.000000 00	0,000000 00
5	0,000000 00	0.000000 00	0,000000 00
6	0,000000 00	0.000000 00	0,000000 00
7	0,000000 00	0.000000 00	0,000000 00
8	0,000000 00	0.000000 00	0,000000 00
9	0,000000 00	0.494270 03	0,000000 00
10	0,000000 00	0.127710 04	0,000000 00
11	0,000000 00	0.212450 04	-0,496480 04
12	0,000000 00	0.000000 00	0,000000 00
13	0,000000 00	0.212870 04	-0,896440 04
14	0,000000 00	0.129010 04	0,000000 00
15	0,000000 00	0.516530 03	0,000000 00
16	0,000000 00	0.000000 00	0,000000 00
17	0,000000 00	0.000000 00	0,000000 00
18	0,000000 00	0.000000 00	0,000000 00
19	0,000000 00	0.000000 00	0,000000 00
20	0,000000 00	0.000000 00	0,000000 00
21	0,000000 00	0.516530 03	0,000000 00
22	0,000000 00	0.129010 04	0,000000 00
23	0,000000 00	0.212870 04	-0.896440 04
24	0,000000 00	0.000000 00	0,000000 00

YIELDING (NGL=3)

ELEM # REINF.STEEL (D+T+B) & LAYERS

1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
10	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
11	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
13	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
14	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
15	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
16	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
17	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
18	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
19	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
20	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
21	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
22	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
23	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
24	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

CHECKING ELEMENTS

ELEMENT # 6

#	POSITION	LAYER AREA	STRAIN	STRESS	INST.MODULUS
30	0,000000 00	0.000000 00	0,000000000 00	0,000000000 00	0,350000000 07
29	0,000000 00	0.000000 00	0,000000000 00	0,000000000 00	0,350000000 07
28	0,000000 00	0.000000 00	0,000000000 00	0,000000000 00	0,350000000 07
27	0,000000 00	0.000000 00	0,000000000 00	0,000000000 00	0,350000000 07
26	0,000000 00	0.000000 00	0,000000000 00	0,000000000 00	0,350000000 07
25	0,000000 00	0.000000 00	0,000000000 00	0,000000000 00	0,350000000 07
24	0,000000 00	0.000000 00	0,000000000 00	0,000000000 00	0,350000000 07
23	0,000000 00	0.000000 00	0,000000000 00	0,000000000 00	0,350000000 07
22	0,000000 00	0.000000 00	0,000000000 00	0,000000000 00	0,350000000 07
21	0,000000 00	0.000000 00	0,000000000 00	0,000000000 00	0,350000000 07
20	0,529000 02	0.440000 02	-0,106947940-04	-0,481265710 02	0,450000000 07
19	0,507000 02	0.440000 02	-0,204728110-04	-0,921276510 02	0,450000000 07
18	0,485000 02	0.440000 02	-0,302508290-04	-0,136128730 03	0,450000000 07
17	0,463000 02	0.440000 02	-0,400288470-04	-0,180129810 03	0,450000000 07
16	0,441000 02	0.440000 02	-0,498068650-04	-0,224130890 03	0,450000000 07
15	0,419000 02	0.240000 02	-0,613627040-04	-0,276132170 03	0,450000000 07
14	0,385000 02	0.240000 02	-0,746983640-04	-0,336133640 03	0,450000000 07
13	0,365000 02	0.240000 02	-0,880300250-04	-0,396135110 03	0,450000000 07
12	0,325000 02	0.240000 02	-0,101363690-03	-0,456136580 03	0,450000000 07
11	0,295000 02	0.240000 02	-0,114697350-03	-0,516138060 03	0,450000000 07
10	0,265000 02	0.240000 02	-0,128031010-03	-0,576139530 03	0,450000000 07
9	0,235000 02	0.240000 02	-0,141364670-03	-0,636141005 03	0,450000000 07
8	0,205000 02	0.240000 02	-0,154698330-03	-0,696142470 03	0,450000000 07
7	0,175000 02	0.240000 02	-0,168031990-03	-0,756143950 03	0,450000000 07
6	0,145000 02	0.240000 02	-0,181365650-03	-0,816145420 03	0,450000000 07
5	0,117000 02	0.676000 02	-0,193810400-03	-0,872146790 03	0,450000000 07
4	0,910000 01	0.676000 02	-0,205366240-03	-0,924148070 03	0,450000000 07
3	0,650000 01	0.676000 02	-0,216922080-03	-0,976149350 03	0,450000000 07
2	0,390000 01	0.676000 02	-0,228477920-03	-0,102815060 04	0,450000000 07
1	0,130000 01	0.676000 02	-0,240033760-03	-0,108015190 04	0,450000000 07

ELEMENT # 18

#	POSITION	LAYER AREA	STRAIN	STRESS	INST.MODULUS
30	0.000000 00	0.000000 00	0.000000000 00	0.000000000 00	0.350000000 07
29	0.000000 00	0.000000 00	0.000000000 00	0.000000000 00	0.350000000 07
28	0.000000 00	0.000000 00	0.000000000 00	0.000000000 00	0.350000000 07
27	0.000000 00	0.000000 00	0.000000000 00	0.000000000 00	0.350000000 07
26	0.000000 00	0.000000 00	0.000000000 00	0.000000000 00	0.350000000 07
25	0.000000 00	0.000000 00	0.000000000 00	0.000000000 00	0.350000000 07
24	0.000000 00	0.000000 00	0.000000000 00	0.000000000 00	0.350000000 07
23	0.000000 00	0.000000 00	0.000000000 00	0.000000000 00	0.350000000 07
22	0.000000 00	0.000000 00	0.000000000 00	0.000000000 00	0.350000000 07
21	0.000000 00	0.000000 00	0.000000000 00	0.000000000 00	0.350000000 07
20	0.529000 02	0.440000 02	-0.875623490-05	-0.394120570 02	0.450000000 07
19	0.507000 02	0.440000 02	-0.196865060-04	-0.884092790 02	0.450000000 07
18	0.485000 02	0.440000 02	-0.286147780-04	-0.128766500 03	0.450000000 07
17	0.463000 02	0.440000 02	-0.385430490-04	-0.173443720 03	0.450000000 07
16	0.441000 02	0.440000 02	-0.484713210-04	-0.218120940 03	0.450000000 07
15	0.415000 02	0.240000 02	-0.602047330-04	-0.270921300 03	0.450000000 07
14	0.385000 02	0.240000 02	-0.737432850-04	-0.331844780 03	0.450000000 07
13	0.355000 02	0.240000 02	-0.872818370-04	-0.392768270 03	0.450000000 07
12	0.325000 02	0.240000 02	-0.100820390-03	-0.453691750 03	0.450000000 07
11	0.295000 02	0.240000 02	-0.114358940-03	-0.514615240 03	0.450000000 07
10	0.265000 02	0.240000 02	-0.127897490-03	-0.575538740 03	0.450000000 07
9	0.235000 02	0.240000 02	-0.141436050-03	-0.636462200 03	0.450000000 07
8	0.205000 02	0.240000 02	-0.154974600-03	-0.697385690 03	0.450000000 07
7	0.175000 02	0.240000 02	-0.168513150-03	-0.758309170 03	0.450000000 07
6	0.145000 02	0.240000 02	-0.182051700-03	-0.819232660 03	0.450000000 07
5	0.117000 02	0.676000 02	-0.194687680-03	-0.876094560 03	0.450000000 07
4	0.910000 01	0.676000 02	-0.206421100-03	-0.928894930 03	0.450000000 07
3	0.650000 01	0.676000 02	-0.218154510-03	-0.981695280 03	0.450000000 07
2	0.390000 01	0.676000 02	-0.229887920-03	-0.103449560 04	0.450000000 07
1	0.130000 01	0.676000 02	-0.241621330-03	-0.108729600 04	0.450000000 07

L O A D C A S E # 3 STEP # 1/ 1 ITER. IN THE STEP= 3 TOTAL # ITER.= 8

N E W S E C T I O N P R O P E R T I E S (TRANSFORMED, TO BOTTOM)

(NON COMPOSITE SECTION)

ELEM #	CENTROID	AREA	AREA MOM.	INERTIA
1	0.2454510 02	0.7980000 03	0.1958700 05	0.7449140 06
2	0.2454510 02	0.7980000 03	0.1958700 05	0.7449140 06
3	0.2454510 02	0.7980000 03	0.1958700 05	0.7449140 06
4	0.2454510 02	0.7980000 03	0.1958700 05	0.7449140 06
5	0.2454510 02	0.7980000 03	0.1958700 05	0.7449140 06
6	0.2454510 02	0.7980000 03	0.1958700 05	0.7449140 06
7	0.2454510 02	0.7980000 03	0.1958700 05	0.7449140 06
8	0.2454510 02	0.7980000 03	0.1958700 05	0.7449140 06
9	0.2496560 02	0.8108890 03	0.2024430 05	0.7784380 06
10	0.2496560 02	0.8108890 03	0.2024430 05	0.7784380 06
11	0.2460630 02	0.8237780 03	0.2027010 05	0.7784900 06
12	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
13	0.2460630 02	0.8237780 03	0.2027010 05	0.7784900 06
14	0.2496560 02	0.8108890 03	0.2024430 05	0.7784380 06
15	0.2496560 02	0.8108890 03	0.2024430 05	0.7784380 06
16	0.2454510 02	0.7980000 03	0.1958700 05	0.7449140 06
17	0.2454510 02	0.7980000 03	0.1958700 05	0.7449140 06
18	0.2454510 02	0.7980000 03	0.1958700 05	0.7449140 06
19	0.2454510 02	0.7980000 03	0.1958700 05	0.7449140 06
20	0.2454510 02	0.7980000 03	0.1958700 05	0.7449140 06
21	0.2496560 02	0.8108890 03	0.2024430 05	0.7784380 06
22	0.2496560 02	0.8108890 03	0.2024430 05	0.7784380 06
23	0.2460630 02	0.8237780 03	0.2027010 05	0.7784900 06
24	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00

NODAL DISPLACEMENTS (+)R,UP,CC

NODE #	X (THIS STEP)	Y (THIS STEP)	THETA (THIS STEP)	X (TOTAL)	Y (TOTAL)	THETA (TOTAL)
1	-0.1479490-01	0.0000000 00	-0.6148450-03	0.9569200-01	0.0000000 00	0.1715280-02
2	-0.1411030-01	-0.4387660-01	-0.5864330-03	0.7210490-01	0.1015410 00	0.1155880-02
3	-0.1219430-01	-0.8374130-01	-0.5069250-03	0.5213320-01	0.1665080 00	0.7447050-03
4	-0.9323250-02	-0.1163270 00	-0.3877830-03	0.3496620-01	0.2103780 00	0.4465170-03
5	-0.5773240-02	-0.1391930 00	-0.2404670-03	0.1979270-01	0.2342320 00	0.2340650-03
6	-0.1820560-02	-0.1507240 00	-0.7643750-04	0.5801860-02	0.2447580 00	0.6810080-04
7	0.2258750-02	-0.1501280 00	0.9284460-04	-0.7617280-02	0.2442500 00	-0.8262490-04
8	0.6188460-02	-0.1374400 00	0.2889190-03	-0.2187570-01	0.2326090 00	-0.2513800-03
9	0.9692400-02	-0.1135190 00	0.4013250-03	-0.3718430-01	0.2073410 00	-0.4713530-03
10	0.1244980-01	-0.8019390-01	0.5137960-03	-0.5458380-01	0.1634580 00	-0.7781770-03
11	0.1424470-01	-0.4005890-01	0.5870060-03	-0.7480950-01	0.9374310-01	-0.1198910-02
12	0.1479490-01	0.0000000 00	0.6097720-03	-0.9569200-01	0.0000000 00	-0.1691200-02
13	-0.1440650-01	0.0000000 00	-0.5945740-03	0.9518140-01	0.0000000 00	0.1704230-02
14	-0.1386090-01	-0.3905740-01	-0.5719980-03	0.7428550-01	0.9459450-01	0.1211390-02
15	-0.1208200-01	-0.7813040-01	-0.4994430-03	0.5401260-01	0.1651580 00	0.7887570-03
16	-0.9352000-02	-0.1104570 00	-0.3880870-03	0.3653280-01	0.2097020 00	0.4786950-03
17	-0.5887370-02	-0.1334780 00	-0.2443130-03	0.2110870-01	0.2353440 00	0.2539690-03
18	-0.2008490-02	-0.1454010 00	-0.8334780-04	0.6901080-02	0.2469680 00	0.7911480-04
19	0.2008490-02	-0.1454010 00	0.8334780-04	-0.6901080-02	0.2469680 00	-0.7911480-04
20	0.5887370-02	-0.1334780 00	0.2443130-03	-0.2110870-01	0.2353440 00	-0.2539690-03
21	0.9352000-02	-0.1104570 00	0.3880870-03	-0.3653280-01	0.2097020 00	-0.4786950-03
22	0.1208200-01	-0.7813020-01	0.4994430-03	-0.5401260-01	0.1651580 00	-0.7887570-03
23	0.1386090-01	-0.3905740-01	0.5719960-03	-0.7428550-01	0.9459450-01	-0.1211390-02
24	0.1440650-01	0.0000000 00	0.5945740-03	-0.9518140-01	0.0000000 00	-0.1704230-02
25	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00

ELEMENT RESULTANT FORCES (+) TENSION,COMP,UP,LEFT UP

(TOTAL)

ELEM #	AXIAL	MOMENT	SHEAR
1	-0.4909600 06	-0.9205660 07	0.3811470 05
2	-0.4909600 06	-0.6738130 07	0.3042770 05
3	-0.4909600 06	-0.4824070 07	0.2274070 05
4	-0.4909600 06	-0.3463470 07	0.1505370 05
5	-0.4909600 06	-0.2656330 07	0.7366720 04
6	-0.4909600 06	-0.2402660 07	-0.3202920 03
7	-0.4909600 06	-0.2702450 07	-0.8007300 04
8	-0.4909600 06	-0.3555710 07	-0.1569430 05
9	-0.4910400 06	-0.5170640 07	-0.2338130 05
10	-0.4910400 06	-0.7130820 07	-0.3106830 05
11	-0.4919730 06	-0.9361360 07	-0.3843500 05
12	0.0000000 00	0.0000000 00	0.0000000 00
13	-0.4919730 06	-0.9371930 07	0.3811470 05
14	-0.4910400 06	-0.7163490 07	0.3074800 05
15	-0.4910400 06	-0.5226370 07	0.2306100 05
16	-0.4909600 06	-0.3634500 07	0.1537400 05
17	-0.4909600 06	-0.2804300 07	0.7687010 04
18	-0.4909600 06	-0.2527570 07	0.6344270-13
19	-0.4909600 06	-0.2804300 07	-0.7687010 04
20	-0.4909600 06	-0.3634500 07	-0.1537400 05
21	-0.4910400 06	-0.5226370 07	-0.2306100 05
22	-0.4910400 06	-0.7163490 07	-0.3074800 05
23	-0.4919730 06	-0.9371930 07	-0.3811470 05
24	0.0000000 00	0.0000000 00	0.0000000 00

NODAL EXTERNAL REACTIONS (+)R,UP,CC

(TOTAL)

NODE #	RX	RY	RZ
1	0.1734000-03	0.3811470 05	-0.9637400-01
12	-0.1734000-03	0.3843500 05	0.7830970-01
13	0.1631800-03	0.3811470 05	-0.7769610-01
24	-0.1631800-03	0.3811470 05	0.7769610-01
25	0.0000000 00	0.0000000 00	0.0000000 00

F I N A L   C A B L E   P R O P E R T I E S   (UP TO THIS STEP)

ELEM #	FORCE	STRESS	STRAIN	E MOD
1	0.491590 06	0.180730 06	0.645460-02	0.280000 08
2	0.492730 06	0.181150 06	0.646970-02	0.280000 08
3	0.493620 06	0.181480 06	0.648130-02	0.280000 08
4	0.494250 06	0.181710 06	0.648960-02	0.280000 08
5	0.494620 06	0.181850 06	0.649450-02	0.280000 08
6	0.494740 06	0.181890 06	0.649600-02	0.280000 08
7	0.494600 06	0.181840 06	0.649420-02	0.280000 08
8	0.494210 06	0.181690 06	0.648900-02	0.280000 08
9	0.493600 06	0.181470 06	0.648110-02	0.280000 08
10	0.492710 06	0.181140 06	0.646940-02	0.280000 08
11	0.492530 06	0.181080 06	0.646700-02	0.280000 08
12	0.000000 00	0.000000 00	0.000000 00	0.000000 00
13	0.492520 06	0.181080 06	0.646700-02	0.280000 08
14	0.492690 06	0.181140 06	0.646920-02	0.280000 08
15	0.493570 06	0.181460 06	0.648080-02	0.280000 08
16	0.494170 06	0.181680 06	0.648860-02	0.280000 08
17	0.494550 06	0.181820 06	0.649360-02	0.280000 08
18	0.494640 06	0.181870 06	0.649530-02	0.280000 08
19	0.494550 06	0.181820 06	0.649360-02	0.280000 08
20	0.494170 06	0.181680 06	0.648860-02	0.280000 08
21	0.493570 06	0.181460 06	0.648080-02	0.280000 08
22	0.492690 06	0.181140 06	0.646920-02	0.280000 08
23	0.492520 06	0.181080 06	0.646700-02	0.280000 08
24	0.000000 00	0.000000 00	0.000000 00	0.000000 00

S T R A I N S   A T   T H E   G I R D E R S

(UP TO THIS STEP)   (MAX. REACHED)

ELEM #	BOTTOM GIRDER	TOP GIRDER	BOTTOM DECK	TOP DECK	BOTTOM GIRDER	TOP GIRDER	BOTTOM DECK	TOP DECK
1	-0.3275990-03	0.9195360-04	0.0000000 00	0.0000000 00	-0.3371090-03	0.1037560-03	0.0000000 00	0.0000000 00
2	-0.2773840-03	0.3099480-04	0.0000000 00	0.0000000 00	-0.3039940-03	0.6401520-04	0.0000000 00	0.0000000 00
3	-0.2384320-03	-0.1629100-04	0.0000000 00	0.0000000 00	-0.2763070-03	-0.9256130-04	0.0000000 00	0.0000000 00
4	-0.2107630-03	-0.4990380-04	0.0000000 00	0.0000000 00	-0.2600480-03	-0.1145730-03	0.0000000 00	0.0000000 00
5	-0.1943170-03	-0.6984360-04	0.0000000 00	0.0000000 00	-0.2492160-03	-0.1275720-03	0.0000000 00	0.0000000 00
6	-0.1891550-03	-0.7611040-04	0.0000000 00	0.0000000 00	-0.2458120-03	-0.1316570-03	0.0000000 00	0.0000000 00
7	-0.1952560-03	-0.6670420-04	0.0000000 00	0.0000000 00	-0.2498350-03	-0.1266290-03	0.0000000 00	0.0000000 00
8	-0.2126200-03	-0.4762500-04	0.0000000 00	0.0000000 00	-0.2612690-03	-0.1130880-03	0.0000000 00	0.0000000 00
9	-0.2416590-03	-0.1154180-04	0.0000000 00	0.0000000 00	-0.2799570-03	-0.8623880-04	0.0000000 00	0.0000000 00
10	-0.2809130-03	0.3463920-04	0.0000000 00	0.0000000 00	-0.3058420-03	0.6461830-04	0.0000000 00	0.0000000 00
11	-0.3164020-03	0.8638140-04	0.0000000 00	0.0000000 00	-0.3247390-03	0.9667010-04	0.0000000 00	0.0000000 00
12	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
13	-0.3166050-03	0.8662760-04	0.0000000 00	0.0000000 00	-0.3248730-03	0.9683050-04	0.0000000 00	0.0000000 00
14	-0.2815670-03	0.3540890-04	0.0000000 00	0.0000000 00	-0.3062730-03	0.6512000-04	0.0000000 00	0.0000000 00
15	-0.2427750-03	-0.1022880-04	0.0000000 00	0.0000000 00	-0.2806920-03	-0.8538290-04	0.0000000 00	0.0000000 00
16	-0.2142230-03	-0.4567850-04	0.0000000 00	0.0000000 00	-0.2623430-03	-0.1118190-03	0.0000000 00	0.0000000 00
17	-0.1973280-03	-0.6618800-04	0.0000000 00	0.0000000 00	-0.2512020-03	-0.1251890-03	0.0000000 00	0.0000000 00
18	-0.1916970-03	-0.7302450-04	0.0000000 00	0.0000000 00	-0.2474660-03	-0.1296450-03	0.0000000 00	0.0000000 00
19	-0.1973280-03	-0.6618800-04	0.0000000 00	0.0000000 00	-0.2512020-03	-0.1251890-03	0.0000000 00	0.0000000 00
20	-0.2142230-03	-0.4567850-04	0.0000000 00	0.0000000 00	-0.2623430-03	-0.1118190-03	0.0000000 00	0.0000000 00
21	-0.2427750-03	-0.1022880-04	0.0000000 00	0.0000000 00	-0.2806920-03	-0.8538290-04	0.0000000 00	0.0000000 00
22	-0.2815670-03	0.3540890-04	0.0000000 00	0.0000000 00	-0.3062730-03	0.6512000-04	0.0000000 00	0.0000000 00
23	-0.3166050-03	0.8662760-04	0.0000000 00	0.0000000 00	-0.3248730-03	0.9683050-04	0.0000000 00	0.0000000 00
24	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00

C R A C K I N G   L E N G T H   &   W I D T H

GIRDER RUPTURE STRAIN = 0.130000-03
DECK RUPTURE STRAIN = 0.130000-03

ELEM #	BOTTOM GIRDER	TOP GIRDER	BOTTOM DECK	TOP DECK	BOTTOM GIRDER	TOP GIRDER	BOTTOM DECK	TOP DECK
1	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
2	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
3	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
4	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
5	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
6	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
7	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
8	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
9	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
10	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
11	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
12	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
13	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
14	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
15	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
16	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
17	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
18	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
19	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
20	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
21	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
22	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
23	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
24	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00

C R A C K I N G   P A T T E R N

GIRDER RUPTURE STRAIN = 0.130000-03
DECK RUPTURE STRAIN = 0.130000-03

ELEM #	L A Y E R S																			
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
10	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
11	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
13	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
14	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
15	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
16	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
17	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
18	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
19	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
20	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
21	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
22	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
23	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
24	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

C R A C K   A N G L E S   (DEGREES)

1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

ELEM #	DECK STEEL	TOP STEEL	BOTTOM STEEL
1	0,000000 00	0.000000 00	0,000000 00
2	0,000000 00	0.000000 00	0,000000 00
3	0,000000 00	0.000000 00	0,000000 00
4	0,000000 00	0.000000 00	0,000000 00
5	0,000000 00	0.000000 00	0,000000 00
6	0,000000 00	0.000000 00	0,000000 00
7	0,000000 00	0.000000 00	0,000000 00
8	0,000000 00	0.000000 00	0,000000 00
9	0,000000 00	-0.705460 03	0,000000 00
10	0,000000 00	0.496150 03	0,000000 00
11	0,000000 00	0.185610 04	-0,874300 04
12	0,000000 00	0.000000 00	0,000000 00
13	0,000000 00	0.186250 04	-0,874850 04
14	0,000000 00	0.516170 03	0,000000 00
15	0,000000 00	-0.671290 03	0,000000 00
16	0,000000 00	0.000000 00	0,000000 00
17	0,000000 00	0.000000 00	0,000000 00
18	0,000000 00	0.000000 00	0,000000 00
19	0,000000 00	0.000000 00	0,000000 00
20	0,000000 00	0.000000 00	0,000000 00
21	0,000000 00	-0.671290 03	0,000000 00
22	0,000000 00	0.516170 03	0,000000 00
23	0,000000 00	0.186250 04	-0,874850 04
24	0,000000 00	0.000000 00	0,000000 00

Y I E L D I N G (NOL=3)

ELEM # REINF.STEEL (UNTIL) & LAYERS

ELEM #																							
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
10	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
11	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
13	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
14	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
15	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
16	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
17	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
18	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
19	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
20	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
21	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
22	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
23	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
24	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

C H E C K I N G E L E M E N T S

ELEMENT # 6

#	POSITION	LAYER AREA	STRAIN	STRESS	INST.MODULUS
30	0,000000 00	0.000000 00	0.000000000 00	0.000000000 00	0.350000000 07
29	0,000000 00	0.000000 00	0.000000000 00	0.000000000 00	0.350000000 07
28	0,000000 00	0.000000 00	0.000000000 00	0.000000000 00	0.350000000 07
27	0,000000 00	0.000000 00	0.000000000 00	0.000000000 00	0.350000000 07
26	0,000000 00	0.000000 00	0.000000000 00	0.000000000 00	0.350000000 07
25	0,000000 00	0.000000 00	0.000000000 00	0.000000000 00	0.350000000 07
24	0,000000 00	0.000000 00	0.000000000 00	0.000000000 00	0.350000000 07
23	0,000000 00	0.000000 00	0.000000000 00	0.000000000 00	0.350000000 07
22	0,000000 00	0.000000 00	0.000000000 00	0.000000000 00	0.350000000 07
21	0,000000 00	0.000000 00	0.000000000 00	0.000000000 00	0.350000000 07
20	0,529000 02	0.440000 02	-0.784131530-04	-0.352859190 03	0.450000000 07
19	0,507000 02	0.440000 02	-0.830186610-04	-0.373583970 03	0.450000000 07
18	0,485000 02	0.440000 02	-0.876241680-04	-0.394308760 03	0.450000000 07
17	0,463000 02	0.440000 02	-0.922296760-04	-0.415033540 03	0.450000000 07
16	0,441000 02	0.440000 02	-0.968351830-04	-0.435758320 03	0.450000000 07
15	0,415000 02	0.240000 02	-0.102278060-03	-0.460251250 03	0.450000000 07
14	0,385000 02	0.240000 02	-0.108558290-03	-0.488512320 03	0.450000000 07
13	0,355000 02	0.240000 02	-0.114838530-03	-0.516773390 03	0.450000000 07
12	0,325000 02	0.240000 02	-0.121118770-03	-0.545034460 03	0.450000000 07
11	0,295000 02	0.240000 02	-0.127399010-03	-0.573295530 03	0.450000000 07
10	0,265000 02	0.240000 02	-0.133679240-03	-0.601556600 03	0.450000000 07
9	0,235000 02	0.240000 02	-0.139959480-03	-0.629817670 03	0.450000000 07
8	0,205000 02	0.240000 02	-0.146239720-03	-0.658078730 03	0.450000000 07
7	0,175000 02	0.240000 02	-0.152519960-03	-0.686339800 03	0.450000000 07
6	0,145000 02	0.240000 02	-0.158800190-03	-0.714600870 03	0.450000000 07
5	0,117000 02	0.676000 02	-0.164661750-03	-0.740977870 03	0.450000000 07
4	0,910000 01	0.676000 02	-0.170104820-03	-0.765471800 03	0.450000000 07
3	0,650000 01	0.676000 02	-0.175547490-03	-0.789963720 03	0.450000000 07
2	0,390000 01	0.676000 02	-0.180990370-03	-0.814456650 03	0.450000000 07
1	0,130000 01	0.676000 02	-0.186433240-03	-0.838949580 03	0.450000000 07

ELEMENT # 18

#	POSITION	LAYER AREA	STRAIN	STRESS	INST.MODULUS
30	0.000000 00	0.000000 00	0.000000000 00	0.000000000 00	0.350000000 07
29	0.000000 00	0.000000 00	0.000000000 00	0.000000000 00	0.350000000 07
28	0.000000 00	0.000000 00	0.000000000 00	0.000000000 00	0.350000000 07
27	0.000000 00	0.000000 00	0.000000000 00	0.000000000 00	0.350000000 07
26	0.000000 00	0.000000 00	0.000000000 00	0.000000000 00	0.350000000 07
25	0.000000 00	0.000000 00	0.000000000 00	0.000000000 00	0.350000000 07
24	0.000000 00	0.000000 00	0.000000000 00	0.000000000 00	0.350000000 07
23	0.000000 00	0.000000 00	0.000000000 00	0.000000000 00	0.350000000 07
22	0.000000 00	0.000000 00	0.000000000 00	0.000000000 00	0.350000000 07
21	0.000000 00	0.000000 00	0.000000000 00	0.000000000 00	0.350000000 07
20	0.529000 02	0.440000 02	-0.754416760-04	-0.339488440 03	0.450000000 07
19	0.507000 02	0.440000 02	-0.802766720-04	-0.361245020 03	0.450000000 07
18	0.485000 02	0.440000 02	-0.851114680-04	-0.383001600 03	0.450000000 07
17	0.463000 02	0.440000 02	-0.899462640-04	-0.404758190 03	0.450000000 07
16	0.441000 02	0.440000 02	-0.947810590-04	-0.426514770 03	0.450000000 07
15	0.415000 02	0.240000 02	-0.100494910-03	-0.452227090 03	0.450000000 07
14	0.385000 02	0.240000 02	-0.107087810-03	-0.481895160 03	0.450000000 07
13	0.355000 02	0.240000 02	-0.113680720-03	-0.511563220 03	0.450000000 07
12	0.325000 02	0.240000 02	-0.120273640-03	-0.541231290 03	0.450000000 07
11	0.295000 02	0.240000 02	-0.126866520-03	-0.570899350 03	0.450000000 07
10	0.265000 02	0.240000 02	-0.133459430-03	-0.600567420 03	0.450000000 07
9	0.235000 02	0.240000 02	-0.140052330-03	-0.630235490 03	0.450000000 07
8	0.205000 02	0.240000 02	-0.146645230-03	-0.659903550 03	0.450000000 07
7	0.175000 02	0.240000 02	-0.153238140-03	-0.689571620 03	0.450000000 07
6	0.145000 02	0.240000 02	-0.159831040-03	-0.719239680 03	0.450000000 07
5	0.117000 02	0.676000 02	-0.165984420-03	-0.746929880 03	0.450000000 07
4	0.910000 01	0.676000 02	-0.171698270-03	-0.772642200 03	0.450000000 07
3	0.650000 01	0.676000 02	-0.177412120-03	-0.798354530 03	0.450000000 07
2	0.390000 01	0.676000 02	-0.183125970-03	-0.824066850 03	0.450000000 07
1	0.130000 01	0.676000 02	-0.188839820-03	-0.849779170 03	0.450000000 07

L O A D C A S E # 4 STEP #123/*** ITER. IN THE STEP= 0 TOTAL # ITER.= 1290

N E W S E C T I O N P R O P E R T I E S (TRANSFORMED, TO BOTTOM)

(COMPOSITE SECTION)

ELEM #	CENTROID	AREA	AREA MOM.	INERTIA
1	0.3500510 02	0.1177500 04	0.4121850 05	0.1978920 07
2	0.3500510 02	0.1177500 04	0.4121850 05	0.1978920 07
3	0.3500510 02	0.1177500 04	0.4121850 05	0.1978920 07
4	0.5388070 02	0.5995000 03	0.3230150 05	0.1753720 07
5	0.5657400 02	0.4235000 03	0.2395910 05	0.1357150 07
6	0.5700000 02	0.3795000 03	0.2163150 05	0.1234000 07
7	0.5657400 02	0.4235000 03	0.2395910 05	0.1357150 07
8	0.5388070 02	0.5995000 03	0.3230150 05	0.1753720 07
9	0.3517830 02	0.1190390 04	0.4187580 05	0.4012440 07
10	0.3517830 02	0.1190390 04	0.4187580 05	0.4012440 07
11	0.3534480 02	0.1232280 04	0.4355460 05	0.2106710 07
12	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
13	0.3534480 02	0.1232280 04	0.4355460 05	0.2106710 07
14	0.3517830 02	0.1190390 04	0.4187580 05	0.4012440 07
15	0.3517830 02	0.1190390 04	0.4187580 05	0.4012440 07
16	0.3500510 02	0.1177500 04	0.4121850 05	0.1978920 07
17	0.3500510 02	0.1177500 04	0.4121850 05	0.1978920 07
18	0.3500510 02	0.1177500 04	0.4121850 05	0.1978920 07
19	0.3500510 02	0.1177500 04	0.4121850 05	0.1978920 07
20	0.3500510 02	0.1177500 04	0.4121850 05	0.1978920 07
21	0.3517830 02	0.1190390 04	0.4187580 05	0.4012440 07
22	0.3517830 02	0.1190390 04	0.4187580 05	0.4012440 07
23	0.3534480 02	0.1232280 04	0.4355460 05	0.2106710 07
24	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00

NODAL DISPLACEMENTS (+)IN,UP,CC

NODE #	X (THIS STEP)	Y (THIS STEP)	THETA (THIS STEP)	X (TOTAL)	Y (TOTAL)	THETA (TOTAL)
1	-0.8047990-02	0.0000000 00	-0.1637690-03	-0.8475800 00	0.0000000 00	-0.1782550-01
2	-0.8052380-02	-0.1035740-01	-0.1638250-03	-0.8659800 00	-0.1304050 01	-0.1823490-01
3	-0.8048700-02	-0.2070960-01	-0.1636460-03	-0.8714270 00	-0.2621340 01	-0.1822630-01
4	-0.8036740-02	-0.3104170-01	-0.1632870-03	-0.8668550 00	-0.3925140 01	-0.1789320-01
5	-0.7840360-02	-0.4122210-01	-0.1394150-03	-0.7453610 00	-0.5124290 01	-0.1529160-01
6	-0.5872140-02	-0.5000000-01	-0.1043590-03	-0.2675450 00	-0.5905240 01	-0.6313270-02
7	0.6166490-02	-0.4990250-01	0.1070590-03	0.4625130 00	-0.5876530 01	0.7106490-02
8	0.8109310-02	-0.4094730-01	0.1416320-03	0.9118430 00	-0.5056440 01	0.1557780-01
9	0.8301300-02	-0.3061150-01	0.1453810-03	0.1026450 01	-0.3841300 01	0.1806810-01
10	0.8310860-02	-0.2012940-01	0.1457190-03	0.1030240 01	-0.2527490 01	0.1834960-01
11	0.8313370-02	-0.9626880-02	0.1458700-03	0.1022810 01	-0.1202430 01	0.1832610-01
12	0.8308900-02	0.0000000 00	0.1458040-03	0.1007120 01	0.0000000 00	0.1795390-01
13	-0.6194660-06	0.0000000 00	0.2070450-07	0.9518080-01	0.0000000 00	0.1764250-02
14	-0.6661020-06	0.1256340-05	0.1736920-07	0.7428880-01	0.9512860-01	0.1211410-02
15	-0.7203720-06	0.2368320-05	0.1352180-07	0.5401190-01	0.1661440 00	0.7687710-03
16	-0.7744240-06	0.3203520-05	0.4680780-08	0.3653200-01	0.2110300 00	0.4787050-03
17	-0.8286030-06	0.3760430-05	0.5791740-08	0.2110790-01	0.2369050 00	0.2539750-03
18	-0.8825640-06	0.4037560-05	0.1909030-08	0.6900260-02	0.2486450 00	0.7911670-04
19	-0.9363050-06	0.4035360-05	-0.1967340-08	-0.6902040-02	0.2486460 00	-0.7911680-04
20	-0.9896270-06	0.3754290-05	-0.5837360-08	-0.2110970-01	0.2369050 00	-0.2539750-03
21	-0.1043130-05	0.3194810-05	-0.9701040-08	-0.3653390-01	0.2110300 00	-0.4787050-03
22	-0.1095870-05	0.2359320-05	-0.1350420-07	-0.5401370-01	0.1561440 00	-0.7687710-03
23	-0.1148390-05	0.1250230-05	-0.1730110-07	-0.7428860-01	0.9512860-01	-0.1211410-02
24	-0.1192820-05	0.0000000 00	-0.2058190-07	-0.9518260-01	0.0000000 00	-0.1764250-02
25	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00

ELEMENT RESULTANT FORCES (+) TENSION,COMP,UP,LEFT UP
(TOTAL)

ELEM #	AXIAL	MOMENT	SHEAR
1	-0.1851050 03	0.6550730 07	0.1821470 06
2	-0.1851050 03	0.1834270 08	0.1454110 06
3	-0.1851050 03	0.2748970 08	0.1086750 06
4	-0.1851050 03	0.3398830 08	0.7194060 05
5	-0.1851050 03	0.3784490 08	0.3520420 05
6	-0.1851050 03	0.3905700 08	-0.1531070 04
7	-0.1851050 03	0.3762440 08	-0.3826630 05
8	-0.1851050 03	0.3354730 08	-0.7500280 05
9	-0.1851050 03	0.2684820 08	-0.1117360 06
10	-0.1851050 03	0.1746080 08	-0.1484730 06
11	-0.1851050 03	0.6054430 07	-0.1836780 06
12	-0.1647180 04	0.0000000 00	0.0000000 00
13	0.5983990 01	0.1257860 07	0.3811480 05
14	0.5983990 01	0.3622370 07	0.3074800 05
15	0.5983990 01	0.5559500 07	0.2306100 05
16	0.5983990 01	0.6943160 07	0.1537400 05
17	0.5983990 01	0.7773360 07	0.7687010 04
18	0.5983990 01	0.8050090 07	0.3122470-02
19	0.5983990 01	0.7773360 07	-0.7687000 04
20	0.5983990 01	0.6943160 07	-0.1537400 05
21	0.5983990 01	0.5559500 07	-0.2306100 05
22	0.5983990 01	0.3622370 07	-0.3074800 05
23	0.5983990 01	0.1257960 07	-0.3811470 05
24	0.5956100 01	0.0000000 00	0.0000000 00

NODAL EXTERNAL REACTIONS (+)IN,UP,CC
(TOTAL)

NODE #	RX	RY	MZ
1	0.1107260-02	0.1820200 06	-0.4798880-02
12	-0.8508810-02	0.1835500 06	0.5602550 00
13	0.9977700-02	0.3811470 05	-0.5578240 00
24	0.4851870-03	0.3811470 05	0.1409780-02
25	-0.3031840-02	0.0000000 00	0.1727980 00

FINAL CABLE PROPERTIES (UP TO THIS STEP)

ELEM #	FORCE	STRESS	STRAIN	E MOD
1	0.496600 06	0.182570 06	0.652040-02	0.280000 08
2	0.506740 06	0.186300 06	0.665370-02	0.280000 08
3	0.514620 06	0.189200 06	0.675710-02	0.280000 08
4	0.629880 06	0.231570 06	0.827040-02	0.280000 08
5	0.689970 06	0.253560 06	0.129440-01	0.310000 07
6	0.707600 06	0.260150 06	0.162590-01	0.120000 08
7	0.686520 06	0.252400 06	0.125700-01	0.310000 07
8	0.623100 06	0.229080 06	0.818140-02	0.280000 08
9	0.514080 06	0.189000 06	0.675000-02	0.280000 08
10	0.506030 06	0.186040 06	0.664440-02	0.280000 08
11	0.496950 06	0.182700 06	0.652510-02	0.280000 08
12	0.000000 00	0.000000 00	0.000000 00	0.000000 00
13	0.492540 06	0.181080 06	0.646700-02	0.280000 08
14	0.492690 06	0.181140 06	0.646920-02	0.280000 08
15	0.493570 06	0.181460 06	0.648080-02	0.280000 08
16	0.494170 06	0.181680 06	0.648860-02	0.280000 08
17	0.494550 06	0.181820 06	0.649360-02	0.280000 08
18	0.494660 06	0.181870 06	0.649530-02	0.280000 08
19	0.494550 06	0.181820 06	0.649360-02	0.280000 08
20	0.494170 06	0.181680 06	0.648860-02	0.280000 08
21	0.493570 06	0.181460 06	0.648080-02	0.280000 08
22	0.492690 06	0.181140 06	0.646920-02	0.280000 08
23	0.492540 06	0.181080 06	0.646700-02	0.280000 08
24	0.000000 00	0.000000 00	0.000000 00	0.000000 00

STRAINS AT THE MEMBERS

	(UP TO THIS STEP)				(MAX. REACHED)			
ELEM #	BOTTOM GIRDER	TOP GIRDER	BOTTOM DECK	TOP DECK	BOTTOM GIRDER	TOP GIRDER	BOTTOM DECK	TOP DECK
1	-0.2556840-03	0.5142280-04	-0.4053080-04	-0.5302430-04	-0.3371090-03	0.1037540-03	-0.4053080-04	-0.5302430-04
2	-0.7593380-04	-0.8245130-04	-0.1134480-03	-0.1484350-03	-0.3039940-03	-0.8245130-04	-0.1134480-03	-0.1484350-03
3	0.6350240-04	-0.1862970-03	-0.1700060-03	-0.2224440-03	-0.2783070-03	-0.1862970-03	-0.1700060-03	-0.2224440-03
4	0.1887420-02	-0.2637940-03	-0.2138900-03	-0.4485620-03	0.1887420-02	-0.2637940-03	-0.2138900-03	-0.4485620-03
5	0.6636330-02	-0.9739920-04	-0.2755560-04	-0.7895780-03	0.6636330-02	-0.2863360-03	-0.2164930-03	-0.7895780-03
6	0.1013970-01	0.7486960-04	0.1509800-03	-0.9798940-03	0.1013970-01	-0.2922920-03	-0.2161820-03	-0.9798940-03
7	0.6240700-02	-0.1127470-03	-0.4404280-04	-0.7640430-03	0.6240700-02	-0.2853280-03	-0.2156240-03	-0.7640430-03
8	0.1591800-02	-0.2594720-03	-0.2118470-03	-0.4358770-03	0.1591800-02	-0.2627160-03	-0.2150930-03	-0.4358770-03
9	0.5268850-04	-0.1749400-03	-0.1633980-03	-0.2142570-03	-0.2799570-03	-0.1749400-03	-0.1633980-03	-0.2142570-03
10	-0.8937280-04	-0.7171430-04	-0.1063530-03	-0.1394530-03	-0.3058820-03	-0.7171430-04	-0.1063530-03	-0.1394530-03
11	-0.2528930-03	0.5159210-04	-0.3478940-04	-0.4571140-04	-0.3247390-03	0.9667010-04	-0.3478940-04	-0.4571140-04
12	0.0000000 00	0.0000000 00	-0.3498080-02	0.6324460-02	0.0000000 00	0.0000000 00	-0.3498080-02	0.6324460-02
13	-0.3166080-03	0.8662960-04	0.2029020-08	0.4332100-08	-0.3248730-03	0.9683050-04	0.6908750-07	0.7940750-07
14	-0.2815680-03	0.3541100-04	0.2130870-08	0.2451340-08	-0.3062730-03	0.6512000-04	0.7255650-07	0.8346880-07
15	-0.2427760-03	-0.1022670-04	0.2129150-08	0.2449090-08	-0.2806920-03	-0.6536290-04	0.7249910-07	0.8339360-07
16	-0.2142240-03	-0.4567630-04	0.2163330-08	0.2487260-08	-0.2623430-03	-0.1118190-03	0.7366410-07	0.8469440-07
17	-0.1973290-03	-0.6618580-04	0.2161590-08	0.2484980-08	-0.2512020-03	-0.1251890-03	0.7360580-07	0.8461850-07
18	-0.1916970-03	-0.7302230-04	0.2159850-08	0.2482700-08	-0.2474880-03	-0.1296450-03	0.7354750-07	0.8454220-07
19	-0.1973290-03	-0.6618580-04	0.2158110-08	0.2480420-08	-0.2512020-03	-0.1251890-03	0.7348930-07	0.8446600-07
20	-0.2142240-03	-0.4567630-04	0.2156370-08	0.2478150-08	-0.2623430-03	-0.1118190-03	0.7343100-07	0.8438970-07
21	-0.2427760-03	-0.1022670-04	0.2118850-08	0.2435590-08	-0.2806920-03	-0.6536290-04	0.7215460-07	0.8294190-07
22	-0.2815680-03	0.3541100-04	0.2117140-08	0.2433340-08	-0.3062730-03	0.6512000-04	0.7209720-07	0.8286660-07
23	-0.3166080-03	0.8662960-04	0.2012970-08	0.2311010-08	-0.3248730-03	0.9683050-04	0.6855070-07	0.7870190-07
24	0.0000000 00	0.0000000 00	0.1352490-07	-0.7044710-08	0.0000000 00	0.0000000 00	0.4606000-08	-0.2399280-08

C R A C K I N G   LENGTH & WIDTH

GIRDER RUPTURE STRAIN = 0.130000-03
DECK RUPTURE STRAIN = 0.130000-03

ELEM #	BOTTOM GIRDER	TOP GIRDER	BOTTOM DECK	TOP DECK	BOTTOM GIRDER	TOP GIRDER	BOTTOM DECK	TOP DECK
1	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
2	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
3	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
4	0.4310170 02	0.0000000 00	0.0000000 00	0.0000000 00	0.1121340 00	0.0000000 00	0.0000000 00	0.0000000 00
5	0.5217640 02	0.0000000 00	0.0000000 00	0.0000000 00	0.4684560 00	0.0000000 00	0.0000000 00	0.0000000 00
6	0.5370420 02	0.0000000 00	0.0000000 00	0.0000000 00	0.7206960 00	0.0000000 00	0.0000000 00	0.0000000 00
7	0.5193680 02	0.0000000 00	0.0000000 00	0.0000000 00	0.4399710 00	0.0000000 00	0.0000000 00	0.0000000 00
8	0.4263940 02	0.0000000 00	0.0000000 00	0.0000000 00	0.1052490 00	0.0000000 00	0.0000000 00	0.0000000 00
9	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
10	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
11	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
12	0.0000000 00	0.0000000 00	0.0000000 00	0.9028270 01	0.0000000 00	0.0000000 00	0.0000000 00	0.7433350-01
13	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
14	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
15	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
16	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
17	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
18	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
19	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
20	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
21	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
22	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
23	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00
24	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00	0.0000000 00

C R A C K I N G   P A T T E R N

GIRDER RUPTURE STRAIN = 0.130000-03
DECK RUPTURE STRAIN = 0.130000-03

ELEM #	L A Y E R S																													
1	1	1	1	1	1	1	1-	1-	1-	1-	1-	1-	1-	1-	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
10	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
11	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0
13	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
14	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
15	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
16	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
17	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
18	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
19	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
20	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
21	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
22	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
23	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
24	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

C R A C K   A N G L E S (DEGREES)

1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

REINF. STEEL STRESSES

ELEM #	DECK STEEL	TOP STEEL	BOTTOM STEEL
1	-0.135650 04	0.000000 00	0.000000 00
2	-0.379730 04	0.000000 00	0.000000 00
3	-0.569050 04	0.000000 00	0.000000 00
4	-0.960360 04	0.000000 00	0.000000 00
5	-0.118480 05	0.000000 00	0.000000 00
6	-0.120190 05	0.000000 00	0.000000 00
7	-0.117170 05	0.000000 00	0.000000 00
8	-0.939200 04	0.000000 00	0.000000 00
9	-0.547600 04	-0.470660 04	0.000000 00
10	-0.356420 04	-0.210820 04	0.000000 00
11	-0.116730 04	0.100560 04	-0.700690 04
12	0.409830 05	0.000000 00	0.000000 00
13	0.632360-01	0.146260 04	-0.474650 04
14	0.664420-01	0.516230 03	0.000000 00
15	0.663840-01	-0.671240 03	0.000000 00
16	0.674340-01	0.000000 00	0.000000 00
17	0.673750-01	0.000000 00	0.000000 00
18	0.673170-01	0.000000 00	0.000000 00
19	0.672590-01	0.000000 00	0.000000 00
20	0.672000-01	0.000000 00	0.000000 00
21	0.660390-01	-0.671240 03	0.000000 00
22	0.659820-01	0.516230 03	0.000000 00
23	0.626980-01	0.186260 04	-0.874650 04
24	0.939630-01	0.000000 00	0.000000 00

YIELDING (NUL=3)

ELEM #	REINF.STEEL (D,T,B) & LAYERS																						
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
10	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
11	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
13	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
14	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
15	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
16	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
17	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
18	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
19	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
20	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
21	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
22	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
23	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
24	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

C H E C K I N G   E L E M E N T S

ELEMENT #   8

#	POSITION	LAYER AREA	STRAIN	STRESS	INST.MODULUS
30	0.597000 02	0.432000 02	-0.923350020-03	-0.323172510 04	0.350000000 07
29	0.591000 02	0.432000 02	-0.810262640-03	-0.283591930 04	0.350000000 07
28	0.585000 02	0.432000 02	-0.697175270-03	-0.244011340 04	0.350000000 07
27	0.579000 02	0.432000 02	-0.584087900-03	-0.204430760 04	0.350000000 07
26	0.573000 02	0.432000 02	-0.471000520-03	-0.164850180 04	0.350000000 07
25	0.567000 02	0.432000 02	-0.357913150-03	-0.125269600 04	0.350000000 07
24	0.561000 02	0.432000 02	-0.244825780-03	-0.856890220 03	0.350000000 07
23	0.555000 02	0.432000 02	-0.131738410-03	-0.461084420 03	0.350000000 07
22	0.549000 02	0.432000 02	-0.186510320-04	-0.652786120 02	0.350000000 07
21	0.543000 02	0.432000 02	0.944363410-04	0.330527190 03	0.350000000 07
20	0.529000 02	0.440000 02	0.279693710-03	0.000000000 00	0.000000000 00
19	0.507000 02	0.440000 02	0.689441920-03	0.000000000 00	0.000000000 00
18	0.485000 02	0.440000 02	0.109999010-02	0.000000000 00	0.000000000 00
17	0.463000 02	0.440000 02	0.151003830-02	0.000000000 00	0.000000000 00
16	0.441000 02	0.440000 02	0.192008650-02	0.000000000 00	0.000000000 00
15	0.415000 02	0.240000 02	0.240468890-02	0.000000000 00	0.000000000 00
14	0.385000 02	0.240000 02	0.296384550-02	0.000000000 00	0.000000000 00
13	0.355000 02	0.240000 02	0.352300220-02	0.000000000 00	0.000000000 00
12	0.325000 02	0.240000 02	0.408215880-02	0.000000000 00	0.000000000 00
11	0.295000 02	0.240000 02	0.464131540-02	0.000000000 00	0.000000000 00
10	0.265000 02	0.240000 02	0.520047210-02	0.000000000 00	0.000000000 00
9	0.235000 02	0.240000 02	0.575962870-02	0.000000000 00	0.000000000 00
8	0.205000 02	0.240000 02	0.631878530-02	0.000000000 00	0.000000000 00
7	0.175000 02	0.240000 02	0.687794190-02	0.000000000 00	0.000000000 00
6	0.145000 02	0.240000 02	0.743709860-02	0.000000000 00	0.000000000 00
5	0.117000 02	0.676000 02	0.795897810-02	0.000000000 00	0.000000000 00
4	0.910000 01	0.676000 02	0.844356050-02	0.000000000 00	0.000000000 00
3	0.650000 01	0.676000 02	0.892816290-02	0.000000000 00	0.000000000 00
2	0.390000 01	0.676000 02	0.941278530-02	0.000000000 00	0.000000000 00
1	0.130000 01	0.676000 02	0.989738770-02	0.000000000 00	0.000000000 00

ELEMENT #   18

#	POSITION	LAYER AREA	STRAIN	STRESS	INST.MODULUS
30	0.597000 02	0.432000 02	0.246656190-08	0.863296660-02	0.350000000 07
29	0.591000 02	0.432000 02	0.243427840-08	0.851996750-02	0.350000000 07
28	0.585000 02	0.432000 02	0.240199100-08	0.840696840-02	0.350000000 07
27	0.579000 02	0.432000 02	0.236970550-08	0.829396920-02	0.350000000 07
26	0.573000 02	0.432000 02	0.233742000-08	0.818097010-02	0.350000000 07
25	0.567000 02	0.432000 02	0.230513460-08	0.806797100-02	0.350000000 07
24	0.561000 02	0.432000 02	0.227284910-08	0.795497180-02	0.350000000 07
23	0.555000 02	0.432000 02	0.224056360-08	0.784197270-02	0.350000000 07
22	0.549000 02	0.432000 02	0.220827840-08	0.772897360-02	0.350000000 07
21	0.543000 02	0.432000 02	0.217599270-08	0.761597440-02	0.350000000 07
20	0.529000 02	0.440000 02	-0.754397750-04	-0.339478990 03	0.450000000 07
19	0.507000 02	0.440000 02	-0.802746890-04	-0.361236100 03	0.450000000 07
18	0.485000 02	0.440000 02	-0.851096040-04	-0.382993220 03	0.450000000 07
17	0.463000 02	0.440000 02	-0.899445180-04	-0.404750330 03	0.450000000 07
16	0.441000 02	0.440000 02	-0.947794320-04	-0.426507450 03	0.450000000 07
15	0.415000 02	0.240000 02	-0.100493420-03	-0.452220400 03	0.450000000 07
14	0.385000 02	0.240000 02	-0.107086490-03	-0.481889190 03	0.450000000 07
13	0.355000 02	0.240000 02	-0.113679550-03	-0.511557980 03	0.450000000 07
12	0.325000 02	0.240000 02	-0.120272620-03	-0.541226780 03	0.450000000 07
11	0.295000 02	0.240000 02	-0.126865680-03	-0.570895570 03	0.450000000 07
10	0.265000 02	0.240000 02	-0.133458750-03	-0.600564360 03	0.450000000 07
9	0.235000 02	0.240000 02	-0.140051810-03	-0.630233150 03	0.450000000 07
8	0.205000 02	0.240000 02	-0.146644880-03	-0.659901940 03	0.450000000 07
7	0.175000 02	0.240000 02	-0.153237940-03	-0.689570740 03	0.450000000 07
6	0.145000 02	0.240000 02	-0.159831010-03	-0.719239530 03	0.450000000 07
5	0.117000 02	0.676000 02	-0.165984530-03	-0.746930400 03	0.450000000 07
4	0.910000 01	0.676000 02	-0.171698520-03	-0.772643360 03	0.450000000 07
3	0.650000 01	0.676000 02	-0.177412510-03	-0.798356310 03	0.450000000 07
2	0.390000 01	0.676000 02	-0.183126500-03	-0.824069260 03	0.450000000 07
1	0.130000 01	0.676000 02	-0.188840490-03	-0.849782220 03	0.450000000 07

M O M E N T - C U R V A T U R E - D E F L E C T I O N

ELEMENT # 6

STEP #	MOMENT	CURVATURE	DEFLECTION	LOAD FACTR	CONT. TIME	ITERATIONS
1	0.5300 07	0.4470-05	-0.2860 00	0.1000 01	0.0000 00	2
2	-0.5270 07	-0.4440-05	0.3450 00	0.1000 01	0.0000 00	3
3	-0.2400 07	-0.2090-05	0.2450 00	0.1000 01	0.0000 00	3
4	-0.4100 06	-0.1280-05	0.1950 00	0.2600-01	0.0000 00	4
5	0.1520 07	-0.5180-06	0.1450 00	0.5120-01	0.0000 00	3
6	0.3440 07	0.2570-06	0.9480-01	0.7630-01	0.0000 00	6
7	0.5370 07	0.1030-05	0.4490-01	0.1010 00	0.0000 00	10
8	0.7490 07	0.1810-05	-0.5060-02	0.1270 00	0.0000 00	8
9	0.9220 07	0.2580-05	-0.5500-01	0.1540 00	0.0000 00	4
10	0.1110 08	0.3350-05	-0.1050 00	0.1770 00	0.0000 00	6
11	0.1310 08	0.4130-05	-0.1550 00	0.2020 00	0.0000 00	4
12	0.1500 08	0.4900-05	-0.2050 00	0.2270 00	0.0000 00	4
13	0.1690 08	0.5680-05	-0.2550 00	0.2520 00	0.0000 00	4
14	0.1890 08	0.6450-05	-0.3050 00	0.2780 00	0.0000 00	9
15	0.2080 08	0.7230-05	-0.3540 00	0.3030 00	0.0000 00	4
16	0.1810 08	0.1480-04	-0.4040 00	0.2680 00	0.0000 00	71
17	0.1880 08	0.1750-04	-0.4540 00	0.2770 00	0.0000 00	5
18	0.1940 08	0.2030-04	-0.5040 00	0.2850 00	0.0000 00	6
19	0.2000 08	0.2310-04	-0.5540 00	0.2930 00	0.0000 00	5
20	0.2060 08	0.2570-04	-0.6040 00	0.3030 00	0.0000 00	4
21	0.2130 08	0.2860-04	-0.6540 00	0.3100 00	0.0000 00	5
22	0.1930 08	0.2080-04	-0.7040 00	0.2830 00	0.0000 00	66
23	0.1960 08	0.2180-04	-0.7540 00	0.2870 00	0.0000 00	6
24	0.2000 08	0.2330-04	-0.8040 00	0.2920 00	0.0000 00	4
25	0.2020 08	0.2420-04	-0.8530 00	0.2950 00	0.0000 00	6
26	0.2060 08	0.2570-04	-0.9030 00	0.3000 00	0.0000 00	4
27	0.2090 08	0.2680-04	-0.9530 00	0.3040 00	0.0000 00	8
28	0.2120 08	0.2790-04	-0.1000 01	0.3080 00	0.0000 00	6
29	0.2150 08	0.2930-04	-0.1050 01	0.3120 00	0.0000 00	4
30	0.2180 08	0.3040-04	-0.1100 01	0.3160 00	0.0000 00	8
31	0.2210 08	0.3150-04	-0.1150 01	0.3200 00	0.0000 00	6
32	0.2250 08	0.3280-04	-0.1200 01	0.3250 00	0.0000 00	4
33	0.2270 08	0.3460-04	-0.1250 01	0.3280 00	0.0000 00	5
34	0.2310 08	0.3590-04	-0.1300 01	0.3330 00	0.0000 00	4
35	0.2340 08	0.3720-04	-0.1350 01	0.3370 00	0.0000 00	4
36	0.2370 08	0.3820-04	-0.1400 01	0.3400 00	0.0000 00	5
37	0.2400 08	0.3950-04	-0.1450 01	0.3450 00	0.0000 00	9
38	0.2430 08	0.4080-04	-0.1500 01	0.3490 00	0.0000 00	4
39	0.2460 08	0.4210-04	-0.1550 01	0.3530 00	0.0000 00	4
40	0.2470 08	0.4550-04	-0.1600 01	0.3540 00	0.0000 00	20
41	0.2490 08	0.4810-04	-0.1650 01	0.3560 00	0.0000 00	4
42	0.2500 08	0.5080-04	-0.1700 01	0.3580 00	0.0000 00	4
43	0.2500 08	0.5480-04	-0.1750 01	0.3580 00	0.0000 00	8
44	0.2520 08	0.5760-04	-0.1800 01	0.3600 00	0.0000 00	4
45	0.2530 08	0.6040-04	-0.1850 01	0.3620 00	0.0000 00	4
46	0.2540 08	0.6330-04	-0.1900 01	0.3630 00	0.0000 00	4
47	0.2560 08	0.6610-04	-0.1950 01	0.3650 00	0.0000 00	4
48	0.2550 08	0.7010-04	-0.2000 01	0.3650 00	0.0000 00	8
49	0.2580 08	0.7310-04	-0.2050 01	0.3660 00	0.0000 00	4
50	0.2580 08	0.7610-04	-0.2100 01	0.3680 00	0.0000 00	4
51	0.2580 08	0.7730-04	-0.2150 01	0.3680 00	0.0000 00	32
52	0.2590 08	0.7960-04	-0.2200 01	0.3690 00	0.0000 00	4
53	0.2600 08	0.8180-04	-0.2250 01	0.3710 00	0.0000 00	8
54	0.2600 08	0.8290-04	-0.2300 01	0.3710 00	0.0000 00	35
55	0.2610 08	0.8480-04	-0.2350 01	0.3720 00	0.0000 00	4
56	0.2620 08	0.8670-04	-0.2400 01	0.3730 00	0.0000 00	4
57	0.2620 08	0.8850-04	-0.2450 01	0.3740 00	0.0000 00	4
58	0.2630 08	0.9040-04	-0.2500 01	0.3750 00	0.0000 00	4
59	0.2630 08	0.9080-04	-0.2540 01	0.3750 00	0.0000 00	10
60	0.2630 08	0.9170-04	-0.2590 01	0.3750 00	0.0000 00	4

61	0.2640 08	0.9340-04	-0.2640 01	0.3760 00	0.0000 00	4
62	0.2650 08	0.9510-04	-0.2690 01	0.3770 00	0.0000 00	4
63	0.2640 08	0.9760-04	-0.2750 01	0.3760 00	0.0000 00	11
64	0.2650 08	0.9940-04	-0.2800 01	0.3770 00	0.0000 00	4
65	0.2650 08	0.1010-03	-0.2850 01	0.3780 00	0.0000 00	4
66	0.2630 08	0.9550-04	-0.2880 01	0.3750 00	0.0000 00	427
67	0.2640 08	0.9710-04	-0.2930 01	0.3760 00	0.0000 00	4
68	0.2640 08	0.9880-04	-0.2980 01	0.3770 00	0.0000 00	4
69	0.2650 08	0.1010-03	-0.3030 01	0.3770 00	0.0000 00	4
70	0.2650 08	0.1020-03	-0.3080 01	0.3780 00	0.0000 00	4
71	0.2660 08	0.1040-03	-0.3130 01	0.3790 00	0.0000 00	4
72	0.2670 08	0.1060-03	-0.3180 01	0.3790 00	0.0000 00	4
73	0.2670 08	0.1070-03	-0.3230 01	0.3800 00	0.0000 00	4
74	0.2680 08	0.1090-03	-0.3280 01	0.3810 00	0.0000 00	4
75	0.2680 08	0.1090-03	-0.3320 01	0.3810 00	0.0000 00	10
76	0.2680 08	0.1100-03	-0.3370 01	0.3810 00	0.0000 00	4
77	0.2690 08	0.1120-03	-0.3420 01	0.3820 00	0.0000 00	4
78	0.2690 08	0.1130-03	-0.3470 01	0.3830 00	0.0000 00	4
79	0.2700 08	0.1150-03	-0.3520 01	0.3830 00	0.0000 00	4
80	0.2700 08	0.1170-03	-0.3570 01	0.3840 00	0.0000 00	5
81	0.2700 08	0.1170-03	-0.3630 01	0.3840 00	0.0000 00	11
82	0.2700 08	0.1180-03	-0.3680 01	0.3850 00	0.0000 00	4
83	0.2690 08	0.1140-03	-0.3740 01	0.3830 00	0.0000 00	229
84	0.2700 08	0.1160-03	-0.3790 01	0.3840 00	0.0000 00	4
85	0.2700 08	0.1170-03	-0.3840 01	0.3840 00	0.0000 00	4
86	0.2710 08	0.1190-03	-0.3890 01	0.3850 00	0.0000 00	4
87	0.2710 08	0.1200-03	-0.3940 01	0.3860 00	0.0000 00	4
88	0.2720 08	0.1220-03	-0.3990 01	0.3860 00	0.0000 00	4
89	0.2720 08	0.1230-03	-0.4040 01	0.3870 00	0.0000 00	4
90	0.2730 08	0.1250-03	-0.4090 01	0.3870 00	0.0000 00	4
91	0.2730 08	0.1260-03	-0.4140 01	0.3880 00	0.0000 00	4
92	0.2730 08	0.1280-03	-0.4190 01	0.3890 00	0.0000 00	4
93	0.2740 08	0.1290-03	-0.4240 01	0.3890 00	0.0000 00	4
94	0.2740 08	0.1310-03	-0.4290 01	0.3900 00	0.0000 00	4
95	0.2750 08	0.1320-03	-0.4340 01	0.3900 00	0.0000 00	4
96	0.2750 08	0.1340-03	-0.4390 01	0.3910 00	0.0000 00	4
97	0.2760 08	0.1350-03	-0.4440 01	0.3920 00	0.0000 00	4
98	0.2760 08	0.1360-03	-0.4490 01	0.3920 00	0.0000 00	4
99	0.2760 08	0.1360-03	-0.4540 01	0.3920 00	0.0000 00	9
100	0.2770 08	0.1380-03	-0.4590 01	0.3930 00	0.0000 00	4
101	0.2770 08	0.1390-03	-0.4640 01	0.3930 00	0.0000 00	4
102	0.2780 08	0.1400-03	-0.4690 01	0.3940 00	0.0000 00	6
103	0.2780 08	0.1420-03	-0.4740 01	0.3940 00	0.0000 00	4
104	0.2780 08	0.1430-03	-0.4790 01	0.3950 00	0.0000 00	4
105	0.2780 08	0.1430-03	-0.4840 01	0.3950 00	0.0000 00	9
106	0.2790 08	0.1450-03	-0.4890 01	0.3960 00	0.0000 00	4
107	0.2790 08	0.1460-03	-0.4940 01	0.3960 00	0.0000 00	4
108	0.2800 08	0.1470-03	-0.4990 01	0.3970 00	0.0000 00	4
109	0.2800 08	0.1490-03	-0.5040 01	0.3970 00	0.0000 00	4
110	0.2810 08	0.1500-03	-0.5090 01	0.3980 00	0.0000 00	4
111	0.2810 08	0.1510-03	-0.5140 01	0.3980 00	0.0000 00	4
112	0.2810 08	0.1530-03	-0.5190 01	0.3990 00	0.0000 00	4
113	0.2810 08	0.1560-03	-0.5240 01	0.3990 00	0.0000 00	8
114	0.2820 08	0.1580-03	-0.5290 01	0.3990 00	0.0000 00	4
115	0.2820 08	0.1590-03	-0.5340 01	0.4000 00	0.0000 00	11
116	0.2830 08	0.1600-03	-0.5390 01	0.4010 00	0.0000 00	4
117	0.2830 08	0.1620-03	-0.5440 01	0.4010 00	0.0000 00	4
118	0.2830 08	0.1630-03	-0.5490 01	0.4020 00	0.0000 00	4
119	0.2840 08	0.1660-03	-0.5540 01	0.4020 00	0.0000 00	15
120	0.2840 08	0.1690-03	-0.5590 01	0.4020 00	0.0000 00	4
121	0.2840 08	0.1720-03	-0.5640 01	0.4020 00	0.0000 00	4
122	0.2840 08	0.1750-03	-0.5690 01	0.4020 00	0.0000 00	4
123	0.2840 08	0.1780-03	-0.5740 01	0.4030 00	0.0000 00	4
124	0.2840 08	0.1810-03	-0.5790 01	0.4030 00	0.0000 00	9
125	0.2850 08	0.1830-03	-0.5840 01	0.4030 00	0.0000 00	3
126	0.3910 08	0.1860-03	-0.5890 01	0.4030 00	0.0000 00	0

*** CONCRETE ULTIMATE STRAIN HAS BEEN REACHED ***

ELEMENT # 18

STEP #	MOMENT	CURVATURE	DEFLECTION	LOAD FACTR	CONT. TIME	ITERATIONS
1	0,5220 07	0.4400-05	-0,2760 00	0.1000 01	0,0000 00	2
2	-0,5350 07	-0.4510-05	0,3920 00	0.1000 01	0,0000 00	3
3	-0,2530 07	-0.2200-05	0,2470 00	0.1000 01	0,0000 00	3
4	-0,2530 07	-0.2200-05	0,2490 00	0.2600-01	0,0000 00	4
5	-0,2530 07	-0.2200-05	0,2490 00	0.5120-01	0,0000 00	3
6	-0,2530 07	-0.2200-05	0,2490 00	0.7630-01	0,0000 00	6
7	-0,2530 07	-0.2200-05	0,2490 00	0.1010 00	0,0000 00	10
8	-0,2530 07	-0.2200-05	0,2490 00	0.1270 00	0,0000 00	8
9	-0,2530 07	-0.2200-05	0,2490 00	0.1540 00	0,0000 00	4
10	-0,2530 07	-0.2200-05	0,2490 00	0.1770 00	0,0000 00	8
11	-0,2530 07	-0.2200-05	0,2490 00	0.2020 00	0,0000 00	4
12	-0,2530 07	-0.2200-05	0,2490 00	0.2270 00	0,0000 00	4
13	-0,2530 07	-0.2200-05	0,2490 00	0.2520 00	0,0000 00	4
14	-0,2530 07	-0.2200-05	0,2490 00	0.2740 00	0,0000 00	9
15	-0,2530 07	-0.2200-05	0,2490 00	0.3030 00	0,0000 00	4
16	-0,2530 07	-0.2200-05	0,2490 00	0.2660 00	0,0000 00	71
17	-0,2530 07	-0.2200-05	0,2490 00	0.2770 00	0,0000 00	6
18	-0,2530 07	-0.2200-05	0,2490 00	0.2850 00	0,0000 00	6
19	-0,2530 07	-0.2200-05	0,2490 00	0.2930 00	0,0000 00	5
20	-0,2530 07	-0.2200-05	0,2490 00	0.3030 00	0,0000 00	4
21	-0,2530 07	-0.2200-05	0,2490 00	0.3100 00	0,0000 00	5
22	-0,2530 07	-0.2200-05	0,2490 00	0.2830 00	0,0000 00	46
23	-0,2530 07	-0.2200-05	0,2490 00	0.2870 00	0,0000 00	6
24	-0,2530 07	-0.2200-05	0,2490 00	0.2920 00	0,0000 00	4
25	-0,2530 07	-0.2200-05	0,2490 00	0.2950 00	0,0000 00	6
26	-0,2530 07	-0.2200-05	0,2490 00	0.3000 00	0,0000 00	4
27	-0,2530 07	-0.2200-05	0,2490 00	0.3040 00	0,0000 00	6
28	-0,2530 07	-0.2200-05	0,2490 00	0.3060 00	0,0000 00	6
29	-0,2530 07	-0.2200-05	0,2490 00	0.3120 00	0,0000 00	4
30	-0,2530 07	-0.2200-05	0,2490 00	0.3160 00	0,0000 00	6
31	-0,2530 07	-0.2200-05	0,2490 00	0.3200 00	0,0000 00	6
32	-0,2530 07	-0.2200-05	0,2490 00	0.3250 00	0,0000 00	4
33	-0,2530 07	-0.2200-05	0,2490 00	0.3280 00	0,0000 00	5
34	-0,2530 07	-0.2200-05	0,2490 00	0.3330 00	0,0000 00	4
35	-0,2530 07	-0.2200-05	0,2490 00	0.3370 00	0,0000 00	64
36	-0,2530 07	-0.2200-05	0,2490 00	0.3400 00	0,0000 00	5
37	-0,2530 07	-0.2200-05	0,2490 00	0.3450 00	0,0000 00	9
38	-0,2530 07	-0.2200-05	0,2490 00	0.3490 00	0,0000 00	4
39	-0,2530 07	-0.2200-05	0,2490 00	0.3530 00	0,0000 00	4
40	-0,2530 07	-0.2200-05	0,2490 00	0.3540 00	0,0000 00	20
41	-0,2530 07	-0.2200-05	0,2490 00	0.3560 00	0,0000 00	4
42	-0,2530 07	-0.2200-05	0,2490 00	0.3580 00	0,0000 00	4
43	-0,2530 07	-0.2200-05	0,2490 00	0.3580 00	0,0000 00	8
44	-0,2530 07	-0.2200-05	0,2490 00	0.3600 00	0,0000 00	4
45	-0,2530 07	-0.2200-05	0,2490 00	0.3620 00	0,0000 00	4
46	-0,2530 07	-0.2200-05	0,2490 00	0.3630 00	0,0000 00	4
47	-0,2530 07	-0.2200-05	0,2490 00	0.3650 00	0,0000 00	4
48	-0,2530 07	-0.2200-05	0,2490 00	0.3650 00	0,0000 00	8
49	-0,2530 07	-0.2200-05	0,2490 00	0.3660 00	0,0000 00	4
50	-0,2530 07	-0.2200-05	0,2490 00	0.3680 00	0,0000 00	4
51	-0,2530 07	-0.2200-05	0,2490 00	0.3680 00	0,0000 00	32
52	-0,2530 07	-0.2200-05	0,2490 00	0.3690 00	0,0000 00	4
53	-0,2530 07	-0.2200-05	0,2490 00	0.3710 00	0,0000 00	8
54	-0,2530 07	-0.2200-05	0,2490 00	0.3710 00	0,0000 00	35
55	-0,2530 07	-0.2200-05	0,2490 00	0.3720 00	0,0000 00	4
56	-0,2530 07	-0.2200-05	0,2490 00	0.3730 00	0,0000 00	4
57	-0,2530 07	-0.2200-05	0,2490 00	0.3740 00	0,0000 00	4
58	-0,2530 07	-0.2200-05	0,2490 00	0.3750 00	0,0000 00	4
59	-0,2530 07	-0.2200-05	0,2490 00	0.3750 00	0,0000 00	10
60	-0,2530 07	-0.2200-05	0,2490 00	0.3750 00	0,0000 00	4
61	-0,2530 07	-0.2200-05	0,2490 00	0.3760 00	0,0000 00	4
62	-0,2530 07	-0.2200-05	0,2490 00	0.3770 00	0,0000 00	4
63	-0,2530 07	-0.2200-05	0,2490 00	0.3760 00	0,0000 00	11
64	-0,2530 07	-0.2200-05	0,2490 00	0.3770 00	0,0000 00	4
65	-0,2530 07	-0.2200-05	0,2490 00	0.3780 00	0,0000 00	4
66	-0,2530 07	-0.2200-05	0,2490 00	0.3750 00	0,0000 00	227
67	-0,2530 07	-0.2200-05	0,2490 00	0.3760 00	0,0000 00	4
68	-0,2530 07	-0.2200-05	0,2490 00	0.3770 00	0,0000 00	4
69	-0,2530 07	-0.2200-05	0,2490 00	0.3770 00	0,0000 00	4
70	-0,2530 07	-0.2200-05	0,2490 00	0.3780 00	0,0000 00	4
71	-0,2530 07	-0.2200-05	0,2490 00	0.3790 00	0,0000 00	4
72	-0,2530 07	-0.2200-05	0,2490 00	0.3790 00	0,0000 00	4
73	-0,2530 07	-0.2200-05	0,2490 00	0.3800 00	0,0000 00	4
74	-0,2530 07	-0.2200-05	0,2490 00	0.3810 00	0,0000 00	4
75	-0,2530 07	-0.2200-05	0,2490 00	0.3810 00	0,0000 00	10
76	-0,2530 07	-0.2200-05	0,2490 00	0.3810 00	0,0000 00	4
77	-0,2530 07	-0.2200-05	0,2490 00	0.3820 00	0,0000 00	4

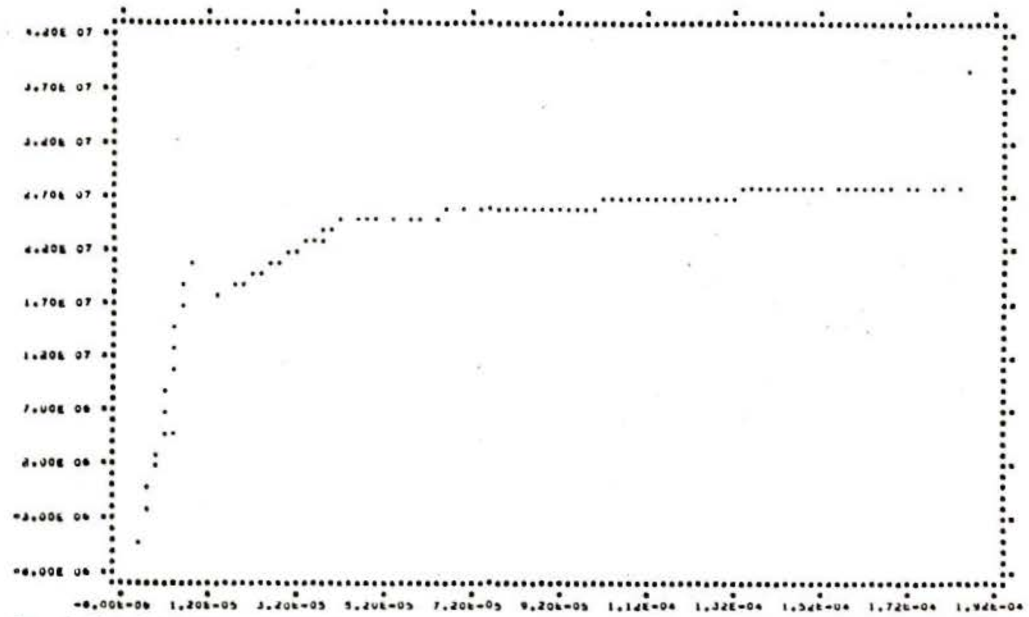
78	-0.2530 07	-0.2200-05	0.2490 00	0.3830 00	0.0000 00	4
79	-0.2530 07	-0.2200-05	0.2490 00	0.3830 00	0.0000 00	4
80	-0.2530 07	-0.2200-05	0.2490 00	0.3840 00	0.0000 00	5
81	-0.2530 07	-0.2200-05	0.2490 00	0.3840 00	0.0000 00	11
82	-0.2530 07	-0.2200-05	0.2490 00	0.3850 00	0.0000 00	4
83	-0.2530 07	-0.2200-05	0.2490 00	0.3850 00	0.0000 00	229
84	-0.2530 07	-0.2200-05	0.2490 00	0.3840 00	0.0000 00	4
85	-0.2530 07	-0.2200-05	0.2490 00	0.3840 00	0.0000 00	4
86	-0.2530 07	-0.2200-05	0.2490 00	0.3850 00	0.0000 00	4
87	-0.2530 07	-0.2200-05	0.2490 00	0.3860 00	0.0000 00	4
88	-0.2530 07	-0.2200-05	0.2490 00	0.3860 00	0.0000 00	4
89	-0.2530 07	-0.2200-05	0.2490 00	0.3870 00	0.0000 00	4
90	-0.2530 07	-0.2200-05	0.2490 00	0.3870 00	0.0000 00	4
91	-0.2530 07	-0.2200-05	0.2490 00	0.3880 00	0.0000 00	4
92	-0.2530 07	-0.2200-05	0.2490 00	0.3890 00	0.0000 00	4
93	-0.2530 07	-0.2200-05	0.2490 00	0.3890 00	0.0000 00	4
94	-0.2530 07	-0.2200-05	0.2490 00	0.3900 00	0.0000 00	4
95	-0.2530 07	-0.2200-05	0.2490 00	0.3900 00	0.0000 00	4
96	-0.2530 07	-0.2200-05	0.2490 00	0.3910 00	0.0000 00	4
97	-0.2530 07	-0.2200-05	0.2490 00	0.3920 00	0.0000 00	4
98	-0.2530 07	-0.2200-05	0.2490 00	0.3920 00	0.0000 00	4
99	-0.2530 07	-0.2200-05	0.2490 00	0.3920 00	0.0000 00	9
100	-0.2530 07	-0.2200-05	0.2490 00	0.3930 00	0.0000 00	4
101	-0.2530 07	-0.2200-05	0.2490 00	0.3930 00	0.0000 00	4
102	-0.2530 07	-0.2200-05	0.2490 00	0.3940 00	0.0000 00	4
103	-0.2530 07	-0.2200-05	0.2490 00	0.3940 00	0.0000 00	4
104	-0.2530 07	-0.2200-05	0.2490 00	0.3950 00	0.0000 00	4
105	-0.2530 07	-0.2200-05	0.2490 00	0.3950 00	0.0000 00	9
106	-0.2530 07	-0.2200-05	0.2490 00	0.3960 00	0.0000 00	4
107	-0.2530 07	-0.2200-05	0.2490 00	0.3960 00	0.0000 00	4
108	-0.2530 07	-0.2200-05	0.2490 00	0.3970 00	0.0000 00	4
109	-0.2530 07	-0.2200-05	0.2490 00	0.3970 00	0.0000 00	4
110	-0.2530 07	-0.2200-05	0.2490 00	0.3980 00	0.0000 00	4
111	-0.2530 07	-0.2200-05	0.2490 00	0.3980 00	0.0000 00	4
112	-0.2530 07	-0.2200-05	0.2490 00	0.3990 00	0.0000 00	4
113	-0.2530 07	-0.2200-05	0.2490 00	0.3990 00	0.0000 00	8
114	-0.2530 07	-0.2200-05	0.2490 00	0.3990 00	0.0000 00	4
115	-0.2530 07	-0.2200-05	0.2490 00	0.4000 00	0.0000 00	11
116	-0.2530 07	-0.2200-05	0.2490 00	0.4010 00	0.0000 00	4
117	-0.2530 07	-0.2200-05	0.2490 00	0.4010 00	0.0000 00	4
118	-0.2530 07	-0.2200-05	0.2490 00	0.4020 00	0.0000 00	4
119	-0.2530 07	-0.2200-05	0.2490 00	0.4020 00	0.0000 00	15
120	-0.2530 07	-0.2200-05	0.2490 00	0.4020 00	0.0000 00	4
121	-0.2530 07	-0.2200-05	0.2490 00	0.4020 00	0.0000 00	4
122	-0.2530 07	-0.2200-05	0.2490 00	0.4020 00	0.0000 00	4
123	-0.2530 07	-0.2200-05	0.2490 00	0.4030 00	0.0000 00	4
124	-0.2530 07	-0.2200-05	0.2490 00	0.4030 00	0.0000 00	9
125	-0.2530 07	-0.2200-05	0.2490 00	0.4030 00	0.0000 00	3
126	0.8050 07	-0.2200-05	0.2490 00	0.4030 00	0.0000 00	0

*** CONCRETE ULTIMATE STRAIN HAS BEEN REACHED ***

SUPPORT REACTIONS

ITEM	SP 1 WP 2	SP 2 WP 2	SP 3 WP 2	SP 4 WP 2	SP 5 WP 1	SP 5 WP 2	SP 5 WP 3	SP
1	0.2470 05	0.2490 05	0.2470 05	0.2470 05	0.0000 00	0.0000 00	0.0000 00	
2	0.2470 05	0.2490 05	0.2470 05	0.2470 05	0.0000 00	0.0000 00	0.0000 00	
3	0.3810 05	0.3840 05	0.3810 05	0.3810 05	0.0000 00	0.0000 00	0.0000 00	
4	0.4740 05	0.4780 05	0.3810 05	0.3810 05	0.1220-03	0.0000 00	-0.6970-02	
5	0.5640 05	0.5690 05	0.3810 05	0.3810 05	0.2850-02	0.0000 00	-0.1620 00	
6	0.6540 05	0.6590 05	0.3810 05	0.3810 05	-0.3340-04	0.0000 00	0.1910-02	
7	0.7430 05	0.7500 05	0.3810 05	0.3810 05	-0.8920-05	0.0000 00	0.5080-03	
8	0.8330 05	0.8400 05	0.3810 05	0.3810 05	-0.1660-04	0.0000 00	0.9480-03	
9	0.9230 05	0.9310 05	0.3810 05	0.3810 05	-0.3980-04	0.0000 00	0.2270-02	
10	0.1010 06	0.1020 06	0.3810 05	0.3810 05	-0.3790-04	0.0000 00	0.2160-02	
11	0.1100 06	0.1110 06	0.3810 05	0.3810 05	-0.4020-04	0.0000 00	0.2290-02	
12	0.1190 06	0.1200 06	0.3810 05	0.3810 05	-0.4020-04	0.0000 00	0.2290-02	
13	0.1280 06	0.1290 06	0.3810 05	0.3810 05	-0.4020-04	0.0000 00	0.2290-02	
14	0.1370 06	0.1380 06	0.3810 05	0.3810 05	-0.1280-04	0.0000 00	0.7470-03	
15	0.1460 06	0.1470 06	0.3810 05	0.3810 05	-0.3690-04	0.0000 00	0.2110-02	
16	0.1340 06	0.1350 06	0.3810 05	0.3810 05	-0.5660-04	0.0000 00	0.3230-02	
17	0.1370 06	0.1380 06	0.3810 05	0.3810 05	-0.8220-04	0.0000 00	0.4680-02	
18	0.1400 06	0.1410 06	0.3810 05	0.3810 05	-0.5380-04	0.0000 00	0.3070-02	
19	0.1430 06	0.1440 06	0.3810 05	0.3810 05	-0.4670-03	0.0000 00	0.2660-01	
20	0.1460 06	0.1470 06	0.3810 05	0.3810 05	-0.2970-04	0.0000 00	0.1690-02	
21	0.1490 06	0.1500 06	0.3810 05	0.3810 05	-0.3210-03	0.0000 00	0.1830-01	
22	0.1390 06	0.1400 06	0.3810 05	0.3810 05	0.3670-04	0.0000 00	-0.2090-02	
23	0.1400 06	0.1420 06	0.3810 05	0.3810 05	-0.2230-03	0.0000 00	0.1270-01	
24	0.1420 06	0.1440 06	0.3810 05	0.3810 05	-0.2960-04	0.0000 00	0.1690-02	
25	0.1430 06	0.1450 06	0.3810 05	0.3810 05	-0.1540-03	0.0000 00	0.8810-02	
26	0.1450 06	0.1460 06	0.3810 05	0.3810 05	-0.2980-04	0.0000 00	0.1700-02	
27	0.1470 06	0.1480 06	0.3810 05	0.3810 05	-0.2110-03	0.0000 00	0.1200-01	
28	0.1480 06	0.1490 06	0.3810 05	0.3810 05	-0.5480-06	0.0000 00	0.3120-04	
29	0.1500 06	0.1510 06	0.3810 05	0.3810 05	-0.3000-04	0.0000 00	0.1710-02	
30	0.1510 06	0.1520 06	0.3810 05	0.3810 05	-0.9740-04	0.0000 00	0.5550-02	
31	0.1520 06	0.1540 06	0.3810 05	0.3810 05	-0.1180-04	0.0000 00	0.6700-03	
32	0.1540 06	0.1550 06	0.3810 05	0.3810 05	-0.3030-04	0.0000 00	0.1720-02	
33	0.1550 06	0.1570 06	0.3810 05	0.3810 05	-0.3280-03	0.0000 00	0.1870-01	
34	0.1570 06	0.1580 06	0.3810 05	0.3810 05	-0.3030-04	0.0000 00	0.1730-02	
35	0.1580 06	0.1600 06	0.3810 05	0.3810 05	-0.3030-04	0.0000 00	0.1730-02	
36	0.1600 06	0.1610 06	0.3810 05	0.3810 05	-0.4200-03	0.0000 00	0.2400-01	
37	0.1610 06	0.1630 06	0.3810 05	0.3810 05	-0.3950-04	0.0000 00	0.2250-02	
38	0.1630 06	0.1640 06	0.3810 05	0.3810 05	-0.2710-04	0.0000 00	0.1540-02	
39	0.1640 06	0.1660 06	0.3810 05	0.3810 05	-0.2710-04	0.0000 00	0.1540-02	
40	0.1650 06	0.1660 06	0.3810 05	0.3810 05	-0.8990-04	0.0000 00	0.5130-02	
41	0.1650 06	0.1670 06	0.3810 05	0.3810 05	-0.2380-04	0.0000 00	0.1360-02	
42	0.1660 06	0.1670 06	0.3810 05	0.3810 05	-0.2380-04	0.0000 00	0.1360-02	
43	0.1660 06	0.1670 06	0.3810 05	0.3810 05	-0.5750-04	0.0000 00	0.3280-02	
44	0.1670 06	0.1680 06	0.3810 05	0.3810 05	-0.2360-04	0.0000 00	0.1350-02	
45	0.1670 06	0.1690 06	0.3810 05	0.3810 05	-0.2360-04	0.0000 00	0.1350-02	
46	0.1680 06	0.1690 06	0.3810 05	0.3810 05	-0.2360-04	0.0000 00	0.1350-02	
47	0.1680 06	0.1700 06	0.3810 05	0.3810 05	-0.2360-04	0.0000 00	0.1350-02	
48	0.1680 06	0.1700 06	0.3810 05	0.3810 05	-0.3250-04	0.0000 00	0.1850-02	
49	0.1690 06	0.1700 06	0.3810 05	0.3810 05	-0.2370-04	0.0000 00	0.1350-02	
50	0.1690 06	0.1710 06	0.3810 05	0.3810 05	-0.2370-04	0.0000 00	0.1350-02	
51	0.1700 06	0.1710 06	0.3810 05	0.3810 05	-0.1470-03	0.0000 00	0.8390-02	
52	0.1700 06	0.1710 06	0.3810 05	0.3810 05	-0.1730-03	0.0000 00	0.9840-02	
53	0.1700 06	0.1720 06	0.3810 05	0.3810 05	-0.6640-04	0.0000 00	0.3780-02	
54	0.1710 06	0.1720 06	0.3810 05	0.3810 05	0.1770-03	0.0000 00	-0.1010-01	
55	0.1710 06	0.1720 06	0.3810 05	0.3810 05	-0.6240-04	0.0000 00	0.3550-02	
56	0.1710 06	0.1730 06	0.3810 05	0.3810 05	-0.6240-04	0.0000 00	0.3550-02	
57	0.1720 06	0.1730 06	0.3810 05	0.3810 05	-0.6240-04	0.0000 00	0.3550-02	
58	0.1720 06	0.1730 06	0.3810 05	0.3810 05	-0.6240-04	0.0000 00	0.3550-02	
59	0.1720 06	0.1730 06	0.3810 05	0.3810 05	-0.2210-03	0.0000 00	0.1260-01	
60	0.1720 06	0.1740 06	0.3810 05	0.3810 05	-0.6710-04	0.0000 00	0.3830-02	
61	0.1720 06	0.1740 06	0.3810 05	0.3810 05	-0.6710-04	0.0000 00	0.3830-02	
62	0.1730 06	0.1740 06	0.3810 05	0.3810 05	-0.6710-04	0.0000 00	0.3830-02	
63	0.1720 06	0.1740 06	0.3810 05	0.3810 05	0.6170-04	0.0000 00	-0.3520-02	
64	0.1730 06	0.1740 06	0.3810 05	0.3810 05	-0.6470-04	0.0000 00	0.3690-02	
65	0.1730 06	0.1740 06	0.3810 05	0.3810 05	-0.6470-04	0.0000 00	0.3690-02	
66	0.1720 06	0.1740 06	0.3810 05	0.3810 05	-0.2650-04	0.0000 00	0.1510-02	
67	0.1720 06	0.1740 06	0.3810 05	0.3810 05	-0.2570-03	0.0000 00	0.1460-01	
68	0.1730 06	0.1740 06	0.3810 05	0.3810 05	-0.8270-04	0.0000 00	0.4720-02	
69	0.1730 06	0.1740 06	0.3810 05	0.3810 05	-0.8270-04	0.0000 00	0.4720-02	
70	0.1730 06	0.1750 06	0.3810 05	0.3810 05	-0.8270-04	0.0000 00	0.4720-02	
71	0.1730 06	0.1750 06	0.3810 05	0.3810 05	-0.8270-04	0.0000 00	0.4720-02	
72	0.1740 06	0.1750 06	0.3810 05	0.3810 05	-0.8270-04	0.0000 00	0.4720-02	
73	0.1740 06	0.1750 06	0.3810 05	0.3810 05	-0.8270-04	0.0000 00	0.4720-02	
74	0.1740 06	0.1760 06	0.3810 05	0.3810 05	-0.8270-04	0.0000 00	0.4720-02	
75	0.1740 06	0.1760 06	0.3810 05	0.3810 05	-0.1220-03	0.0000 00	0.6960-02	
76	0.1740 06	0.1760 06	0.3810 05	0.3810 05	-0.8860-04	0.0000 00	0.5050-02	
77	0.1750 06	0.1760 06	0.3810 05	0.3810 05	-0.8860-04	0.0000 00	0.5050-02	
78	0.1750 06	0.1760 06	0.3810 05	0.3810 05	-0.8860-04	0.0000 00	0.5050-02	
79	0.1750 06	0.1760 06	0.3810 05	0.3810 05	-0.8860-04	0.0000 00	0.5050-02	
80	0.1750 06	0.1770 06	0.3810 05	0.3810 05	-0.4060-04	0.0000 00	0.2320-02	
81	0.1750 06	0.1770 06	0.3810 05	0.3810 05	0.1360-04	0.0000 00	-0.7750-03	
82	0.1750 06	0.1770 06	0.3810 05	0.3810 05	-0.9450-04	0.0000 00	0.5380-02	
83	0.1750 06	0.1760 06	0.3810 05	0.3810 05	0.3320-04	0.0000 00	-0.1990-02	
84	0.1750 06	0.1770 06	0.3810 05	0.3810 05	-0.1030-03	0.0000 00	0.5860-02	
85	0.1750 06	0.1770 06	0.3810 05	0.3810 05	-0.1030-03	0.0000 00	0.5860-02	
86	0.1760 06	0.1770 06	0.3810 05	0.3810 05	-0.1030-03	0.0000 00	0.5860-02	
87	0.1760 06	0.1770 06	0.3810 05	0.3810 05	-0.1030-03	0.0000 00	0.5860-02	
88	0.1760 06	0.1770 06	0.3810 05	0.3810 05	-0.1030-03	0.0000 00	0.5860-02	
89	0.1760 06	0.1780 06	0.3810 05	0.3810 05	-0.1030-03	0.0000 00	0.5860-02	
90	0.1760 06	0.1780 06	0.3810 05	0.3810 05	-0.1030-03	0.0000 00	0.5860-02	
91	0.1770 06	0.1780 06	0.3810 05	0.3810 05	-0.1030-03	0.0000 00	0.5860-02	
92	0.1770 06	0.1780 06	0.3810 05	0.3810 05	-0.1030-03	0.0000 00	0.5860-02	
93	0.1770 06	0.1780 06	0.3810 05	0.3810 05	-0.1030-03	0.0000 00	0.5860-02	
94	0.1770 06	0.1790 06	0.3810 05	0.3810 05	-0.1030-03	0.0000 00	0.5860-02	
95	0.1770 06	0.1790 06	0.3810 05	0.3810 05	-0.1030-03	0.0000 00	0.5860-02	
96	0.1780 06	0.1790 06	0.3810 05	0.3810 05	-0.1030-03	0.0000 00	0.5860-02	
97	0.1780 06	0.1790 06	0.3810 05	0.3810 05	-0.1030-03	0.0000 00	0.5860-02	
98	0.1780 06	0.1800 06	0.3810 05	0.3810 05	-0.1030-03	0.0000 00	0.5860-02	
99	0.1780 06	0.1800 06	0.3810 05	0.3810 05	-0.1970-03	0.0000 00	0.1130-01	
100	0.1780 06	0.1800 06	0.3810 05	0.3810 05	-0.1120-03	0.0000 00	0.6370-02	
101	0.1790 06	0.1800 06	0.3810 05	0.3810 05	-0.1120-03	0.0000 00	0.6370-02	
102	0.1790 06	0.1800 06	0.3810 05	0.3810 05	0.7780-04	0.0000 00	-0.4430-02	
103	0.1790 06	0.1800 06	0.3810 05	0.3810 05	-0.1120-03	0.0000 00	0.6380-02	
104	0.1790 06	0.1810 06	0.3810 05	0.3810 05	-0.1120-03	0.0000 00	0.6380-02	
105	0.1790 06	0.1810 06	0.3810 05	0.3810 05	0.1360-03	0.0000 00	-0.7730-02	
106	0.1790 06	0.1810 06	0.3810 05	0.3810 05	-0.1130-03	0.0000 00	0.6410-02	
107	0.1800 06	0.1810 06	0.3810 05	0.3810 05	-0.1130-03	0.0000 00	0.6410-02	
108	0.1800 06	0.1810 06	0.3810 05	0.3810 05	-0.1130-03	0.0000 00	0.6410-02	
109	0.1800 06	0.1810 06	0.3810 05	0.3810 05	-0.1130-03	0.0000 00	0.6410-02	
110	0.1800 06	0.1820 06	0.3810 05	0.3810 05	-0.1130-03	0.0000 00	0.6410-02	
111	0.1800 06	0.1820 06	0.3810 05	0.3810 05	-0.1130-03	0.0000 00	0.6410-02	
112	0.1800 06	0.1820 06	0.3810 05	0.3810 05	-0.1130-03	0.0000 00	0.6410-02	
113	0.1810 06	0.1820 06	0.3810 05	0.3810 05	-0.6040-04	0.0000 00	0.3440-02	
114	0.1810 06	0.1820 06	0.3810 05	0.3810 05	0.7720-03	0.0000 00	-0.4400-01	
115	0.1810 06	0.1820 06	0.3810 05	0.3810 05	-0.4160-04	0.0000 00	0.2370-02	
116	0.1810 06	0.1830 06	0.3810 05	0.3810 05	-0.1170-03	0.0000 00	0.6680-02	
117	0.1810 06	0.1830 06	0.3810 05	0.3810 05	-0.1170-03	0.0000 00	0.6680-02	
118	0.1810 06	0.1830 06	0.3810 05	0.3810 05	-0.1170-03	0.0000 00	0.6680-02	
119	0.1820 06	0.1830 06	0.3810 05	0.3810 05	-0.1730-03	0.0000 00	0.9870-02	
120	0.1820 06	0.1830 06	0.3810 05	0.3810 05	-0.1130-03	0.0000 00	0.6450-02	
121	0.1820 06	0.1830 06	0.3810 05	0.3810 05	-0.1130-03	0.0000 00	0.6450-02	
122	0.1820 06	0.1830 06	0.3810 05	0.3810 05	-0.1130-03	0.0000 00	0.6450-02	
123	0.1820 06	0.1830 06	0.3810 05	0.3810 05	-0.4730-03	0.0000 00	0.2690-01	
124	0.1820 06	0.1830 06	0.3810 05	0.3810 05	-0.2570-04	0.0000 00	0.1460-02	
125	0.1820 06	0.1840 06	0.3810 05	0.3810 05	-0.3030-02	0.0000 00	0.1730 00	

P L O T S



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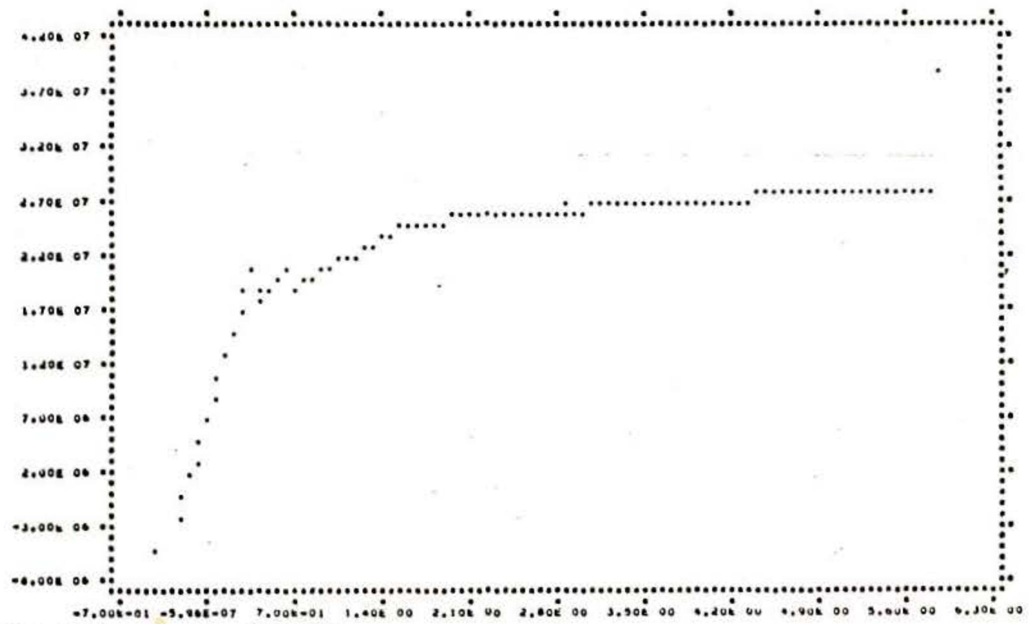
YMAX= 3.90570E 07 YMIN= -5.27392E 06
XINCH= 2.00000E-06 YINCH= 1.00000E 06

ELEM # 6 MOMENT-CURVATURE



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YMAX= 3.90570E 07 YMIN= -5.27392E 06
XINCH= 6.99990E-02 YINCH= 1.00000E 06

ELEM # 6 MOMENT-DEFLECTION